ERL Digital I/O Expansion

User Manual

Version 1.1 Rev 0

Preface

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Contact Information

ERLPhase Power Technologies Ltd.
74 Scurfield Blvd.
Winnipeg, Manitoba, Canada
R3Y 1G4
Website: www.erlphase.com
Email: info@erlphase.com

Technical Support
Email: support@erlphase.com
Tel: 1-204-477-0591

Using This Guide

This User Manual describes the installation and operation of the ERL Digital I/O Expansion device and the accompanying TESLA Control Panel user interface software. It is intended to support the first time user and clarify the details of the equipment.

The manual uses a number of conventions to denote special information:

Example	Describes
Start>Settings>Control Panel	Choose the Control Panel submenu in the Settings submenu on the Start menu.
Right-click	Click the right mouse button.
Recordings	Menu items and tabs are shown in italics.
service	User input or keystrokes are shown in bold.
Text boxes similar to this one	Relate important notes and information.
..	Indicates more screens.

Table of Contents

Preface i
Contact Information i
Using This Guide iii
Table of Contents v
Version Compatibility ix
PC System Requirements and Software Installation xi

1 Overview 1-1

System Description 1-1
Application 1-1
Recording 1-2
Channel Configuration 1-3
Product Features 1-3
Model Options 1-4
Front Panel 1-5
Rear Connections 1-5

2 Connection and Power Up 2-1

Mounting 2-1
Power Supply 2-1
Signal Connections 2-2

3 TESLA Control Panel Installation 3-1

Installing TESLA Control Panel 3-1
Installation on Windows XP and Windows 7 3-2
First Time Start-Up 3-6

4 Communicating with the ERL I/O IED 4-1

IEC 61850 Communication 4-1
Communication Ports 4-4
IRIG-B Time Input 4-5
Communicating with the ERL I/O Expansion (IED) 4-6
Ethernet LAN Link 4-7
USB Link 4-10
Direct Serial Link 4-13
Accessing SCADA Services 4-14
Communication Port Details 4-20

5 Working with TESLA Control Panel 5-1

Device Workspace 5-1
Adding/Editing a Device Workspace Definition 5-3
Online and Offline Operation 5-5
Navigating in TESLA Control Panel 5-6
6 Metering Display 6-1
7 IED Setup Utilities 7-1
Unit Identification 7-2
Communication Port Settings 7-3
Recording Control Settings 7-5
Time Display and Settings 7-8
Password Protection 7-11
8 Configuring the IED 8-1
Managing Configuration Files 8-1
SCADA and DNP Configuration 8-4
IED Configuration Editor 8-4
Identification 8-5
Channels and Triggers 8-6
External Input Channels 8-10
Printing 8-12
9 Record and Log Management 9-1
Recording 9-1
Records 9-1
Event Log 9-5
10 Graphing Records 10-1
Getting Started 10-1
RecordGraph Menu Items 10-4
Digital Channel Status Indicator 10-6
Time Sync Input Status 10-6
Derived External and Virtual Input Channels for TESLA Swing Recordings 10-7
COMTRADE Import 10-7
Print Options 10-7
11 Record Export Utility 11-1
COMTRADE Format 11-3
PTI Format 11-5
Excel (CSV) Format 11-7
IEEE C37.232 TSD File Naming 11-9

12 Maintenance Menu and Error Handling 12-1

Maintenance Menu 12-1

Error Handling 12-5

Appendix A Specifications A-1

Appendix B Hardware Description B-1

Appendix C Glossary C-1

Appendix D Modbus RTU Communication Protocol D-1

Appendix E DNP3 Device Profile E-1

Appendix F Recommended Spare Parts List F-1

Appendix G ERL I/O Expansion Handling and Disposition G-1

Appendix H ERL I/O Expansion Drawings H-1

Appendix I IEC 61850 Implementation for I/O Expansion Unit I-1

Protocol Implementation Conformance Statement (PICS) for I/O Expansion Unit I-1

Model Implementation Conformance Statement (MICS) I-7

Data Mapping Specifications I-21

Index I

Version Compatibility

ERL Digital I/O Expansion Version Compatibility			
I/O Expansion Firmware	**Setting Version**	**TESLA Control Panel**	**ICD File Version**
v1.0	401	v2.5 and greater	v3.0

Please contact ERLPhase Customer Service for complete Revision History.

PC System Requirements and Software Installation

Hardware

The minimum hardware requirements are:

- 1 GHz processor
- 2 GB RAM
- 20 GB available hard disk space
- USB port
- Serial communication port

Operating System

The following software must be installed and functional prior to installing the applications:

- Microsoft Windows XP Professional Service Pack 3 or
- Microsoft Windows 7 Professional Service Pack 1 32-bit or 64-bit

Software Installation

The CD-ROM contains software and the User Manual for the ERL I/O Expansion Control Panel.

Software is installed directly from the CD-ROM to a Windows PC.

The CD-ROM contains the following:

- TESLA Control Panel: Program for the recorder
- ERL I/O Expansion Firmware: Firmware and installation instructions.
- ERL I/O Expansion User Manual: Manual in PDF format
- USB Driver

To Install Software on your Computer

Insert the CD-ROM in your drive. The CD-ROM should open automatically. If the CD-ROM does not open automatically, go to Windows Explorer and find the CD-ROM (usually on D drive). Open the ERLPhase.exe file to launch the CD-ROM.

To install the software on your computer, click the desired item on the screen. The installation program launches automatically. Installation may take a few minutes to start.

To view the ERL I/O Expansion User Manual the user must have Adobe Acrobat on their computer.

Anti-virus/Anti-spyware Software

If an anti-virus/anti-spyware software on your local system identifies any of the ERLPhase applications as a “potential threat”, it will be necessary to configure your anti-virus/anti-software to classify it as “safe” for its proper operation. Please consult the appropriate anti-virus/anti-spyware software documentation to determine the relevant procedure.

Installing TESLA Control Panel

The user must be logged on to the target computer as a user with local administrator privileges to install TESLA Control Panel. Once installed, the user may be logged in as a Limited User, as administrator privileges are not generally required for operation of the program.

Overview

Once these steps are complete, go to the First Time Start-Up section for details on launching TESLA Control Panel (see “First Time Start-Up” on page 3-6).

1 Overview

1.1 System Description

The ERL I/O Expansion Module is a stand-alone digital input/output extension nodal box that supports 128 physical digital inputs (DIs) and 15 output contacts. The ERL I/O Expansion Module uses IEC 61850 GOOSE (Generic Object Oriented Substation Event) station bus (8-1) enabled protocol to publish and subscribe the binary input/output messages with other ERL Devices and other IEDs supporting IEC 61850 GOOSE subscriptions.

The ERL I/O Expansion system consists primarily of the unit hardware and the TESLA Control Panel user interface software.

TESLA Control Panel user interface software provides tools to configure the unit, retrieve and manage records and display real time digital status values. Control Panel also includes RecordGraph, a graphical record display and analysis software tool.

1.2 Application

The ERL I/O Expansion IED is to be used in any application where there are many status (DI) inputs ? such as large substations and generating stations. By communicating these digital input statuses to multiple IEDs in the network it expands their access to such information and is a cheaper alternative to adding additional IEDs. It also reduces the problems associated with having these multiple IEDs communicate with each other.

The ERL I/O IED also provides alarm and control through its 15 output contacts and 15 subscription virtual channels for output contact control

Application with TESLA 4000

TESLA 4000 power system recorder has provision for up to 256 virtual inputs to receive and record the time and status of events contained in the IEC 61850 GOOSE messages published by the ERL I/O IED. These messages are available as records and for oscillography in the same way as the 64 physical digital inputs

Connect two ERL I/O IEDs with one TESLA 4000 to get 256 additional status inputs.

Use the Windows based ERL 61850 IED Configurator to configure and map data between the ERL I/O IED and TESLA 4000. The ERL 61850 IED Configurator can also be used to configure the subscriptions for any other ERL devices

Application with ERL Relays and other Protection IEDs

The ERL I/O Expansion IED can be used to provide access to additional digital input statuses to all ERL relays, and indeed any IED capable of IEC 61850 GOOSE subscription. In large substations and schemes with many status inputs, the ERL I/O Expansion provides a more cost effective option to additional protection IEDs. It also provides cost savings on the wiring between protection panels and increases safety in the substation.

The I/O Expansion IED receives unmodulated or modulated IRIG ?B time and can distribute the IRIG-B signal to 5 other IEDs connected to it. In the event of a loss in the GPS time source, the I/O Expansion IED generates and provides 1pps unmodulated IRIG-B signal across all connected IEDs, thereby ensuring time synchronization across these IEDs which is critical in some protection schemes.

SCADA Application

The I/O Expansion IED communicates with SCADA using DNP3, Modbus or IEC 61850 station bus protocol, acting as an RTU for its digital inputs and output contacts.

1.3 Recording

The I/O Expansion digital inputs are mapped to the logical device triggers for publishing. Any digital input status changes will be published as IEC 61850 GOOSE messages which can be used for triggering recording on TESLA 4000 and on any other IEDs capable of GOOSE subscription.

GOOSE messages published by other IEDs and mapped to the I/O Expansion?s subscription virtual channels shall be used to trigger a recording on the I/O Expansion. The I/O Expansion can be used for recording its own physical digital input status changes in a similar manner.

Refer to “Record and Log Management” on page 9-1 for more information on recording features.

1.4 Channel Configuration

The I/O Expansion IED does not require user configuration for publishing the digital input status changes. The digital inputs 1 to 128 are mapped to DIGRBDR1 ? DIGRBDR128 logical nodes of the logical device triggers in sequential order as marked on the IEDs rear panel.

Status change events for the digital inputs 1 to 128 will be automatically added to the ERL I/O IEDs event log.

The I/O Expansion IEDs subscription features of recording and output contact control requires user configuration using the ERL IEC 61850 Configurator

See “Communicating with the ERL I/O IED” on page 4-1 for more details of the ERL I/O IEDs communications

1.5 Product Features

General

- 128 external (digital) input channels with event tracking which can be published as IEC 61850 GOOSE status messages
- Up to 15 output contacts can be activated by GOOSE or DNP3 Binary Output triggers
- Failure / Service Required contact
- 19" rack-mount format, 4U footprint

User Interface

- Integrated configuration and record management tools
- Offline mode allows configurations to be created and records viewed without connecting to the device
- Record display shows record summaries with trigger event lists.
- Real-time metering display shows all input statuses

Communication Protocols

- Standard TCP/IP communication protocol used to communicate with Control Panel
- SCADA (Supervisory Control and Data Acquisition) protocol DNP3 over Ethernet and RS232 is supported
- IEC 61850 station bus is supported

Time Coordination

- 1 IRIG ?B time input - modulated or unmodulated. Supports IEEE 1344 extensions.
- 5 IRIG-B system time sync outputs for common reference time sharing
- 1 ms event time tagging of events and records
- Time synchronization indicator in each record
- Front panel LED time synchronization indicator

- Primary/Secondary SNTP time source server provisions

Records and Event Log

- Fault records from 0.2 to 15.0 seconds with automatic record extension up to 30.0 seconds under multiple trigger conditions
- Data sample rates for fault recording of 96 samples per cycle
- 500 entry event log (circular)
- Record graphics provide a flexible multi-page interactive display and measurement of all channels
- COMTRADE record export facility

Communication and User Interfaces:

- Front:

  1 Ethernet Port (100BASE ?Tx RJ 45)

  1 USB Port
- Rear:

  2 Ethernet ports 100/1000BASE-T ? Cu or Optical

  5 Ethernet Ports (100/1000BASE-T ? RJ 45)

  5 local time synchronization 2-wire outputs (IRIG-B format),

  1 SCADA RS232

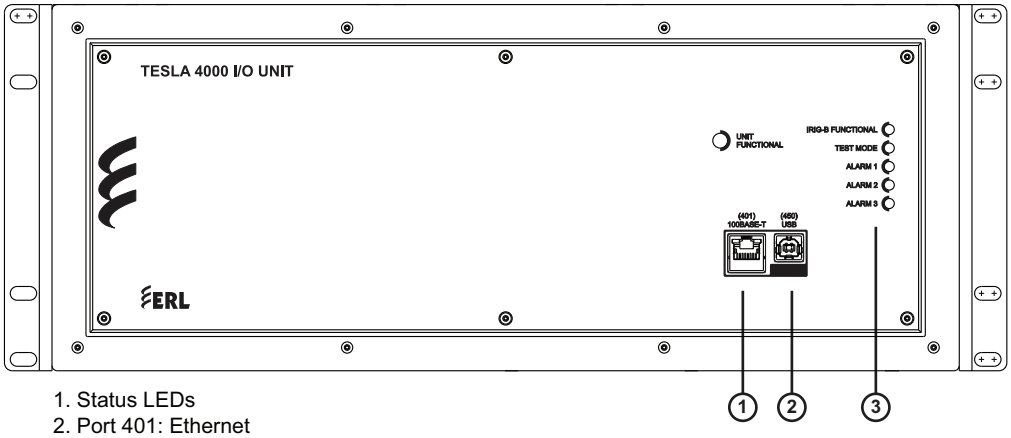
Reliability

- Self-monitoring supervisory software with hardware self-checking circuit and failure contact
- Flash memory for program and storage
- Compliance with IEC EMC standards

1.6 Model Options

Ethernet port configuration and LAN configuration are the primary orderable options available in the ERL I/O Expansion IEDs

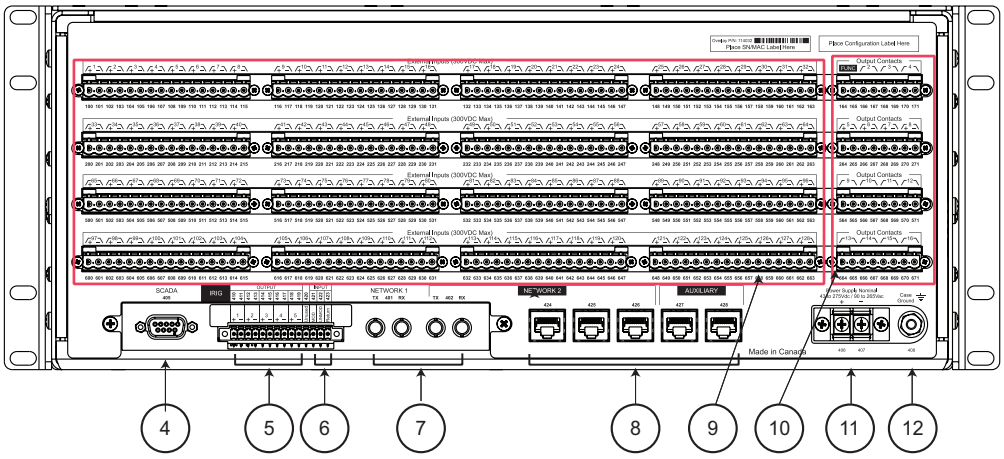
1.7 Front Panel



1. Status LEDs
2. Port 401: Ethernet
3. Port 450: USB

Figure 1.1: Front Panel

1.8 Rear Connections



4. Port 405: EIA 232 SCADA Communication (DNP 3 and Modbus)
5. Ports 410 - 419: System Synch Clock Output, modulated or unmodulated (depending on source)
6. Ports 421 - 423: IRIG B External Clock, modulated or unmodulated
7. Ports 401 – 402: 100/1000 Base-T Ethernet Network
8. Ports 424 – 428: 100/1000 Base-T Ethernet Network
9. Ports 100 – 163, 200 – 263, 500 – 563 and 600 – 663 (128): External (digital) Input Channels
10. Ports 164 – 171, 264 – 271, 564 - 571 and 264 – 271 (16): Output Contacts
11. Port 406 – 407: Power Supply (40-300 Vdc). Handles 48,125 or 250 Vdc or 120 Vac nominal
12. Port 408: Chassis Ground

Figure 1.2: Rear Panel Configuration

2 Connection and Power Up

For drawings, see “ERL I/O Expansion Drawings” in Appendix H.

2.1 Mounting

The ERL I/O Expansion unit is designed to be mounted in a standard 19-inch equipment rack. It is 4 rack units (7.0 inches) high and 12.725 inches deep. An additional 3 inches of depth is required for rear connections and cables.

Case Grounding

WARNING!

To ensure safety and proper operation you must connect the device’s grounding terminal to the station ground. Do not rely on the rack mounting screws to provide case grounding.

Ground the device even when testing.

2.2 Power Supply

A wide range power supply is standard. The nominal operating range is 48-250 Vdc, 100-240 Vac, +/-10%, 50/60 Hz. To protect against a possible short circuit in the supply use an inline fuse or circuit breaker with a 5 A rating. Make the chassis ground connection to ensure proper operation and safety.

There are no power switches on the recorder. When the power supply is connected, the recorder starts its initialization process. See “Installing TESLA Control Panel” on page 3-1 for the start up process details.

The use of an external surge protection device is required to pass the surge immunity requirements of IEC/EN 60255-22-5 Criterion A. ERLPhase recommends either of the following for this function:

ERLPhase p/n: 107898

Manufacturer: Phoenix Contact Ltd.

Manufacturer's p/n: 2858357 (PT 2-PE/S 230AC)

or

ERLPhase p/n: 107899

Manufacturer: Dehn Ltd.

Manufacturer's p/n: 953 200 (DR M 2P 255)

One surge protector can be used to protect multiple units, as long as the current limit of the surge protection device is not exceeded.

Note that this is a consumable item and not covered by ERLPhase warranty.

2.3 Signal Connections

External Input Channels

The device's external inputs are dry inputs intended for use with signals from a 48-250 Vdc station battery. The external inputs are isolated and protected against transient surges. They activate at approximately 32 Vdc.

Alarm Contacts

The ERL I/O Expansion unit has 16 available alarm contacts on the rear of the unit. These are dry contacts and are isolated and protected against transient surges. Contact 1 is a normally closed contact reserved to indicate device failure (contact closure on fail), with the remaining contacts configured as normally open, and available for user configuration. User configurable alarm contacts are accessible through IEC 61850 communications, assigned to logical node OCGGIO1.

IRIG-B Time Signal

The IRIG-B input provisions on the rear of the unit (Pluggable Terminal Block) accepts either modulated or unmodulated IRIG-B time signals, with or without the 1344 extensions.

The IRIG-B outputs are used to synchronize other units that are part of the same system, I.E. an IO Expansion partnered with a TESLA 4000 or as part of a B-PRO Multibus system. The outputs drive whatever is provided on the IRIG inputs (modulated or unmodulated). If a valid IRIG signal is not detected on either input then the outputs will drive an unmodulated IRIG-B output synchronized to the internal real time clock of the unit. The IRIG inputs and outputs should be connected as shown in figure TBD (section 2.3 figure provided) for various configurations.

Communication Ports

See "Communicating with the ERL I/O IED" on page 4-1.

Startup Sequence

Table 2.1: Startup Sequence	
On Power Up	Front panel Test Mode LED turns on to indicate the presence of power
~15-20 seconds after Power Up	Test Mode LED goes off
~25-30 seconds after Power Up	Unit Functional LED turns on. At this point you can log into the unit

Front Panel LEDs

Table 2.2: Front Panel LEDs	
Front Panel LED	**Indications**

Table 2.2: Front Panel LEDs	
Unit Functional	Normally active green LED that is turned on approximately 25-30 seconds after power up, indicating the unit is functional. If an internal fault is detected, the LED is turned off. The LED state corresponds directly with the Failure Contact.
IRIG-B Functional	Green LED that is active when a valid external time synchronizing signal is detected on the IRIG-B port
Test Mode	Normally inactive red LED that turns on immediately on power up and goes off after the self-test has been completed (approximately 15-20 seconds).
Alarm 1	Normally inactive red LED that indicates a failure has been detected by the software. The presence of the Alarm LED means much of the system is functioning and can be accessed for diagnosis.
Alarm 2	Reserved for future use.
Alarm 3	Reserved for future use.

3 TESLA Control Panel Installation

The ERL I/O Expansion CD-ROM contains the following:

- TESLA Control Panel: interface software
- Firmware update with installation instructions
- User Manual in PDF format
- Mechanical drawings in electronic format

3.1 Installing TESLA Control Panel

You must be logged on to the target computer as a user with local administrator privileges to install TESLA Control Panel. Once installed, you may be logged in as a Limited User, as administrator privileges are not generally required for operation of the program.

Overview

Instructions for installing TESLA Control Panel and configuring Windows for its use are covered in the following sections. Separate instructions for each version of Windows Operating System are provided for the above steps. Use the one that is appropriate for your computer.

The procedure has the following parts:

1. Install TESLA Control Panel.
2. Install the Null Modem driver.

> Installation of TESLA Control Panel software may require changes to your Windows system configuration for proper operation. Please review the instructions in this chapter to ensure proper setup.
>
> Once these steps are complete, go to the First Time Start-Up section for details on launching TESLA Control Panel (see “First Time Start-Up” on page 3-6).

3.2 Installation on Windows XP and Windows 7

The user will need to have installed previously ERLPhase's USB driver provided with the installation CD. See section "USB Link" on page 4-10 for instructions.

Step 1: Install TESLA Control Panel Software from CD-ROM

1. Insert the TESLA CD-ROM in your drive.
2. The CD-ROM should start automatically. If it doesn't, go to Windows Explorer and run the "ERLPhase.exe" file at the root of the CD-ROM directory.
3. To install TESLA Control Panel software on your computer, select the *ERL I/O Expansion* icon, then the *Install TESLA Control Panel*. The installation program starts automatically, but may take a few minutes to begin.
4. During installation a prompt appears asking whether your TESLA recorders are 50 Hz or 60 Hz units. For proper operation it is important to select the correct one. If you need to change this in the future, re-install TESLA Control Panel.
5. When the installation is complete, a TESLA Control Panel icon is placed on your desktop. Use the icon to launch Control Panel.

   If you prefer, you can start Control Panel through Windows Start menu (*Start>Programs>ERLPhase>TESLA Control Panel*).

Step 2: Installing Null Modem Driver Software

A virtual software modem called a "Null Modem" must be set up for direct serial cable communication between this computer and an ERL I/O Expansion unit. A Null Modem driver is provided with the device installation CD-ROM.

This section provides step by step instructions on how to install the Null Modem driver. If you are going to communicate with a 4000 series product please ensure that you connect your computer to the front USB port of a powered up 4000 series unit prior to following these steps.

1. Start Windows Control Panel by going to *Start>Control Panel*.
2. Double-click the *Phone and Modem Options* icon.
3. Select the *Modems* tab. Select *Add* to open the Add Hardware Wizard.
4. Select *Don't detect my modem; I will select it from a list,* then select the *Next* button.

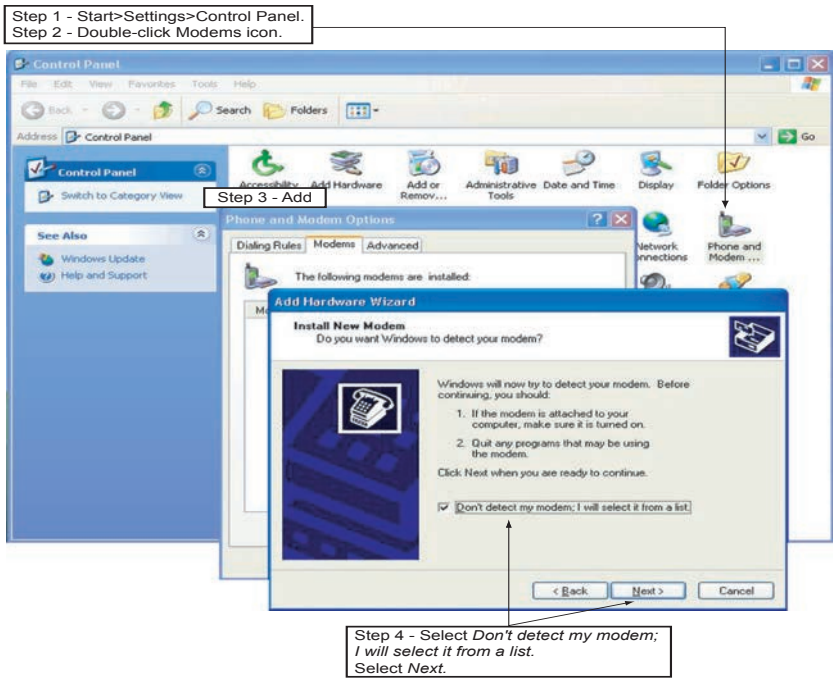

Step 1 - Start>Settings>Control Panel.
Step 2 - Double-click Modems icon.
Step 3 - Add
Step 4 - Select Don't detect my modem; I will select it from a list.
Select Next.
Control Panel
Phone and Modem Options
Dialing Rules
Modems
Advanced
The following modems are installed:
Add Hardware Wizard
Install New Modem
Do you want Windows to detect your modem?
Windows will now try to detect your modem. Before continuing, you should:
1. If the modem is attached to your computer, make sure it is turned on.
2. Quit any programs that may be using the modem.
Click Next when you are ready to continue.
Don't detect my modem; I will select it from a list.
< Back
Next >
Cancel

Figure 3.1: Null Modem Driver Installation

5. Select the *Have Disk* button, select *Browse*. To find the file go to *C:\Program Files\ERLPhase\TESLA Control Panel\Null_mdm.Inf.* Note that directory *Program Files(x86)* is used for Windows 7 64-bit operating systems instead of *Program Files.* Select *OK*. This is the default location for TESLA Control Panel. If you selected a different location to install TESLA Control Panel, you will find the Null Modem driver (Null_mdm.Inf) in that directory.

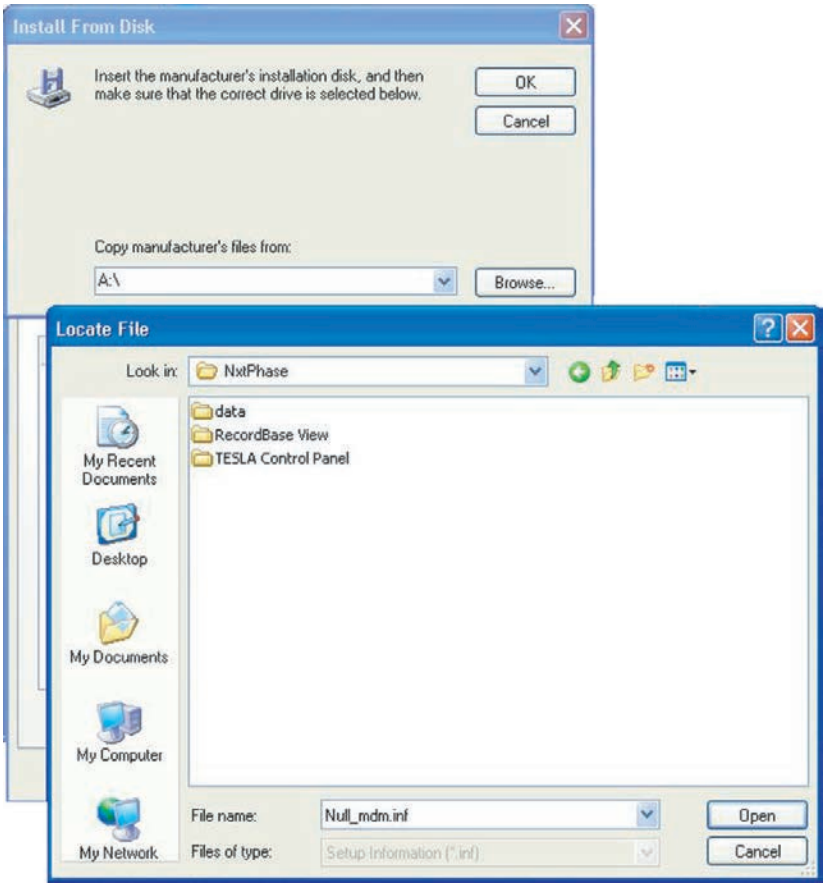


Figure 3.2: Browse for Null_mdm.Inf

6. Select the *ERLPhase Null Modem* driver and select *Next*.
7. Select the serial port you wish to use. You are setting up a serial port to be used for a direct cable connection to a 4000 series device. Typically COM1 or COM2 are available on a PC for this purpose. Select *Next*.

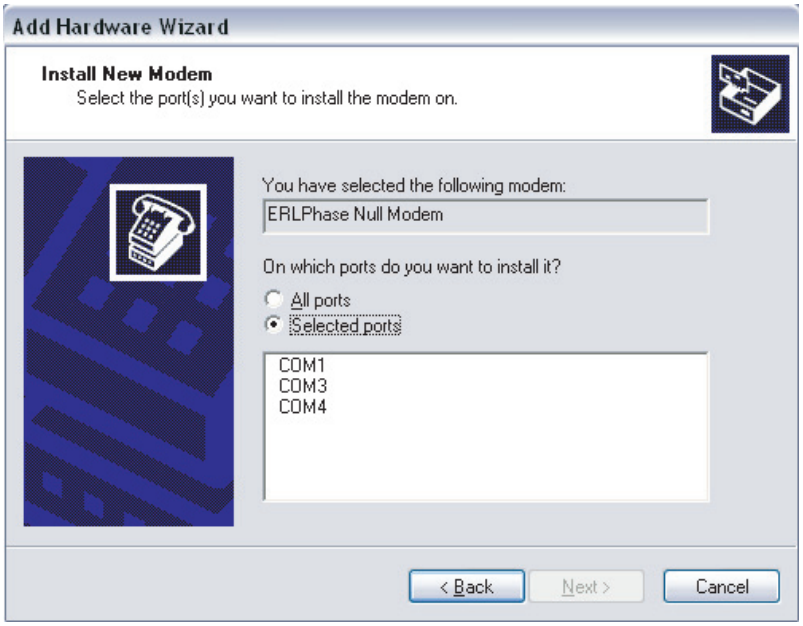


Figure 3.3: Select Serial Port

In Windows XP, you may get a message stating that the Null Modem "has not passed Windows Logo testing" and asking "Do you want to continue the installation?" Select *Continue Anyway* to continue.

8. Select *Finish* and close the Phone and Modem Options and Control Panel dialog boxes.

3.3 First Time Start-Up

Starting TESLA Control Panel

To start TESLA Control Panel, double-click the *TESLA Control Panel* icon placed on your desktop by the installation process or select *Start>Program Files>ERLPhase>TESLA Control Panel.*

Data Location

TESLA Control Panel uses a data location on your computer to store records and settings from your recorders. By default it is *C:\Program Files\ERLPhase\Data,* although you may change this later by using the *File\Data Location* command from the Main Menu (*Program Files(x86*) for Windows 7 64-bit operating systems).

When you change the data location, previously configured IEDs will not be affected. Only newly created IEDs will use the new data location. To edit the data location of existing IEDs use the Main Menu *Edit* button.

Note that recent Microsoft Windows security updates prevent non-Administrative user accounts from storing data under *C:\Program Files (Program Files(x86)* for Windows 7 64-bit operating systems); it may be necessary to change the default record and config storage locations for the IEDs.

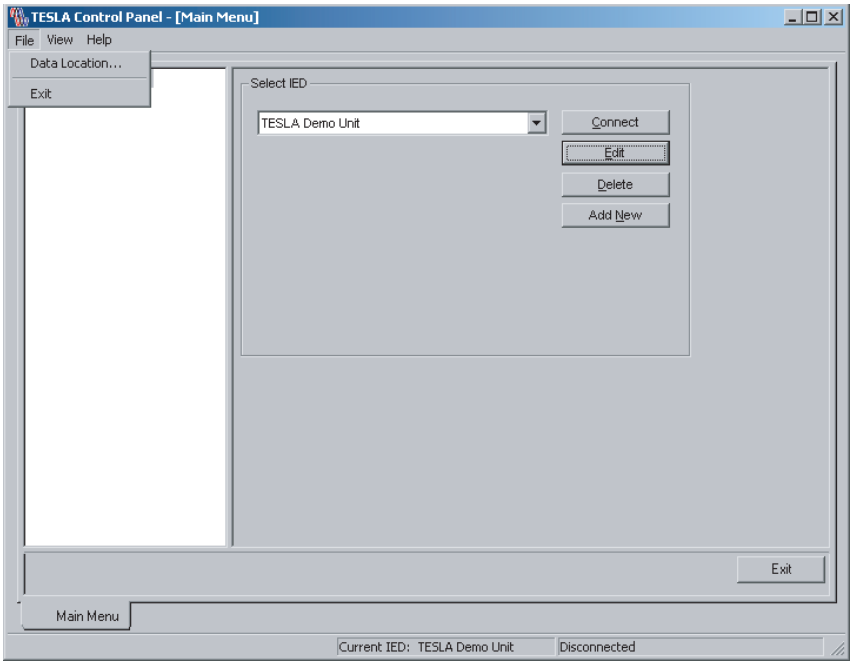


Figure 3.4: Data Location

4 Communicating with the ERL I/O IED

This chapter describes the communication options to communicate with ERL I/O Expansion unit.

4.1 IEC 61850 Communication

The IEC 61850 Standard

The Smart Grid is transforming the electrical power industry by using digital technology to deliver electricity in a more intelligent, efficient and controlled way. Embedded control and communication devices are central to this transformation by adding intelligent automation to electrical networks.

The IEC 61850 standard defines a new protocol that permits substation equipment to communicate with each other. Like many other well-known manufacturers, ERLPhase Power Technologies is dedicated to using IEC 61850-based devices that can be used as part of an open and versatile communications network for substation automation.

The IEC 61850 defines an Ethernet-based protocol used in substations for data communication. Substations implement a number of controllers for protection, measurement, detection, alarms, and monitoring. System implementation is often slowed down by the fact that the controllers produced by different manufacturers are incompatible, since they do not support the same communication protocols. The problems associated with this incompatibility are quite serious, and result in increased costs for protocol integration and system maintenance.

Channel Configuration

The I/O Expansion IED does not require user configuration for publishing the digital input status changes. The digital inputs 1 to 128 are mapped to DIGRBDR1 - DIGRBDR128 logical nodes of the logical device Triggers in sequential order as marked on the IED's rear panel. The ERL IEC 61850 Configurator can be used to customize the default I/O Expansion GOOSE data set and control block configuration.

The I/O Expansion IED does not require user configuration for the SOE logging of the digital input status changes. Status change events for the digital inputs 1 to 128 will be added to the IED's event log. The log messages include digital input number, as marked on the IED's rear panel, and the current digital input status indication (active or inactive). The TESLA Control Panel configuration software can be used to view I/O Expansion events and to customize the default digital input channel configuration including channel names, status indication and log options.

The I/O Expansion IED requires user configuration for the subscription features. The ERL IEC 61850 Configurator shall be used for the I/O Expansion subscription configuration as described below.

To trigger a recording, source of incoming GOOSE record trigger shall be mapped to the SUBSCRGGIO1 of the logical device ExtRcdTriggers. 128 subscription virtual channels, Ind1 to Ind128, are available for external record trig-

gering on the I/O Expansion. Note: there is no correlation between the subscription virtual channels and the physical digital inputs of the I/O Expansion.

To operate an output contact, source of incoming GOOSE output contact control shall be mapped to the SUBSCRGGIO1 of the logical device Output. 15 subscription virtual channels, Ind2 to Ind16 mapped to output contacts 2 to 16 in sequential order as marked on the IED's rear panel, are available to operate output contacts on the I/O Expansion. Note: the output contact 1 is the IED functional output contact and is not controllable via IEC 61850 GOOSE commands. The Ind1 of the Output SUBSCRGGIO1 is not used and is included for compliance with the IEC 61850 requirements.

Implementation Details

The ERL I/O Expansion Module conforms to IEC 61850-8-1, commonly referred to as Station Bus Protocol. Implementation includes the following documents:

- Protocol Implementation Conformance Statement (see "Protocol Implementation Conformance Statement (PICS) for I/O Expansion Unit" on page Appendix I-1).
- Model Implementation Conformance Statement (see "Model Implementation Conformance Statement (MICS)" on page Appendix I-7).

All configurable IEC61850 parameters are available via the Maintenance interface. Note that this effort may already have been completed as part of the steps taken to establish a network maintenance connection to the recorder.

1. Establish a TUI session with the recorder and login as maintenance. The following screen appears.

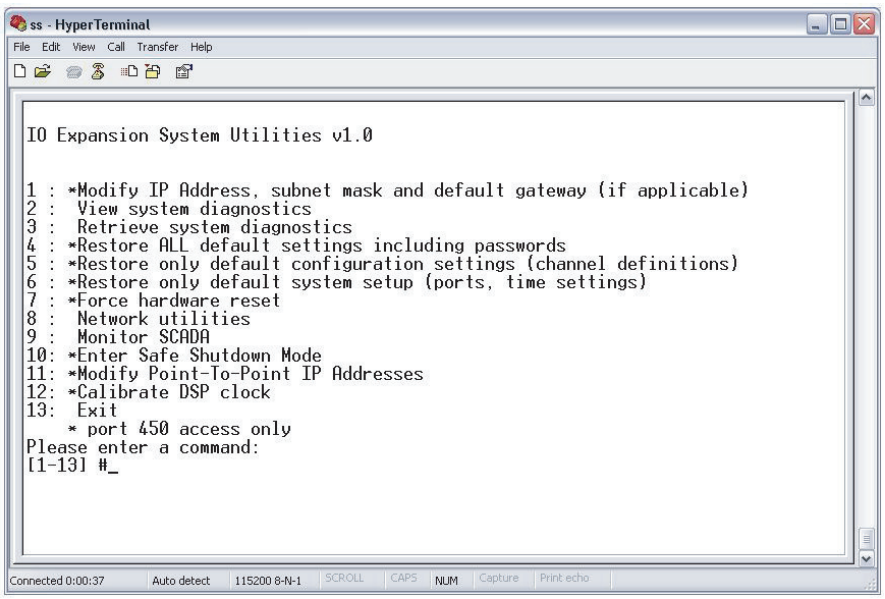

ss - HyperTerminal
File Edit View Call Transfer Help
IO Expansion System Utilities v1.0
1 : *Modify IP Address, subnet mask and default gateway (if applicable)
2 : View system diagnostics
3 : Retrieve system diagnostics
4 : *Restore ALL default settings including passwords
5 : *Restore only default configuration settings (channel definitions)
6 : *Restore only default system setup (ports, time settings)
7 : *Force hardware reset
8 : Network utilities
9 : Monitor SCADA
10: *Enter Safe Shutdown Mode
11: *Modify Point-To-Point IP Addresses
12: *Calibrate DSP clock
13: Exit
* port 450 access only
Please enter a command:
[1-13] #_
Connected 0:00:37
Auto detect
115200 8-N-1
SCROLL
CAPS
NUM
Capture
Print echo

Figure 4.5: Establish a TUI Session with the IED

2. Select the first option by entering the number 1 followed by <Enter>. The following screen appears.

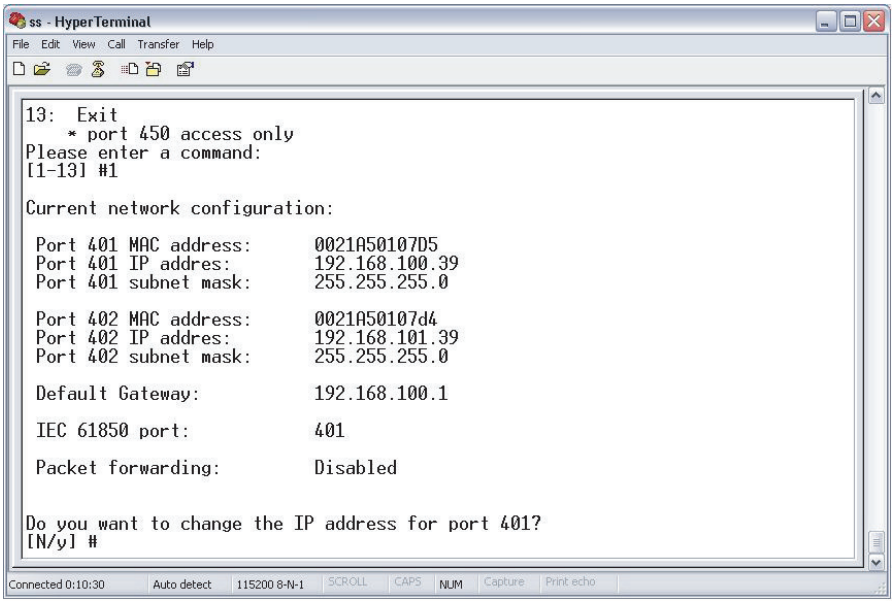


Figure 4.6: New Option 1, Modify IP screen

Note that unit's IP address can be used on the IEC61850 client side for unique unit identification instead of a physical device "PD Name". The publisher configuration is fixed and defined in the ICD file and available for reading to any IEC61850 client. Subscriber functionality is also fixed and supported for the Virtual Inputs only.

4.2 Communication Ports

The ERL I/O Expansion unit has multiple communication ports for local and remote access to its user interface and SCADA services. For port pin-out and cabling information see “Communication Port Details” on page 4-20.

Table 4.1: Communication Ports

Location	Port	Function
Front Panel	401	RJ-45 receptacle, 100BASE-T Ethernet interface. Default IP = 192.168.100.80 Used for user interface access or SCADA access through Ethernet LAN
Front Panel	450	USB-B receptacle, High speed USB 2.0 interface Used for user interface access Default fixed baud rate 115,200 N81 (no parity, 8 data bits, 1 stop bit)
Rear Panel	401	RJ-45 receptacle or ST type optical receptacle (factory configured). 100BASE-T or 100BASE-FX (1300nm, multi-mode) Ethernet interface. Same subnet as front panel port 401 Used for user interface access or DNP SCADA access through Ethernet LAN
Rear Panel	402	RJ-45 receptacle or ST type optical receptacle (factory configured), 100BASE-T or 100BASE-FX (1300nm, multi-mode) Ethernet interface. Default IP = 192.168.101.80 Used for user interface access or DNP SCADA access through Ethernet LAN.
Rear Panel	405	RS-232 DCE female DB9 Used for SCADA communication Default Setting: 19,200 baud O71 (odd parity, 7 data bits, 1 stop bit)
Rear Panel	410	Time Synch Output 1 (+), 2-wire interface, IRIG format
Rear Panel	411	Time Synch Output 1 (-)
Rear Panel	412	Time Synch Output 2 (+), 2-wire interface, IRIG format
Rear Panel	413	Time Synch Output 2 (-)
Rear Panel	414	Time Synch Output 3 (+), 2-wire interface, IRIG format
Rear Panel	415	Time Synch Output 3 (-)
Rear Panel	416	Time Synch Output 4 (+), 2-wire interface, IRIG format
Rear Panel	417	Time Synch Output 4 (-)
Rear Panel	418	Time Synch Output 5 (+), 2-wire interface, IRIG format
Rear Panel	419	Time Synch Output 5 (-)
Rear Panel	420	Unused
Rear Panel	421	IRIG-B Time Synch Input, 2-wire interface, Modulated, 330 ohm impedance
Rear Panel	422	IRIG-B Time Synch Input, 2-wire interface, Un-modulated, 330 ohm impedance

Table 4.1: Communication Ports		
Rear Panel	423	IRIG-B Input Common Return, Modulated/Un-modulated
Rear Panel	424	RJ-45 receptacle, 100BASE-T Ethernet interface, Network 2 (Port 402) connected
Rear Panel	425	RJ-45 receptacle, 100BASE-T Ethernet interface, Network 2 (Port 402) connected
Rear Panel	426	RJ-45 receptacle, 100BASE-T Ethernet interface, Network 2 (Port 402) connected
Rear Panel	427	RJ-45 receptacle, 100BASE-T Ethernet interface Factory configurable Network 1 (Port 401) or Network 2 (Port 402) connected
Rear Panel	428	RJ-45 receptacle, 100BASE-T Ethernet interface Factory configurable Network 1 (Port 401) or Network 2 (Port 402) connected

External converters may be used to convert communication ports and increase the options available for connection to devices and networks. (See “Recommended Spare Parts List” in Appendix F for optional devices available).

4.3 IRIG-B Time Input

The ERL I/O Expansion unit is equipped to handle modulated or un-modulated GPS satellite time IRIG-B signals via two-wire interface. The IRIG-B time signal input is connected to the port 421 (Modulated) or port 422 (Un-modulated) provisions on the unit rear panel with the common return connected to port 423. When the IRIG-B signal is provided to the device and is enabled in the settings through the user interface, the IRIG-B functional LED comes on and the IED clock is referenced to this signal. No settings are required to differentiate between modulated or un-modulated signals; this is automatically detected by the device.

Enable or disable the IEEE 1344 extension using TESLA Control Panel in the *Utilities* > *Time tab*. The enabled mode receives the year from the IRIG-B signal. Disable this setting, if the available IRIG-B signal has no year extension.

4.4 Communicating with the ERL I/O Expansion (IED)

You can connect to the device to access its user interface and SCADA services by:

- Front USB 2.0 interface (user interface)
- Front or rear copper or optical Ethernet network link (user interface, SCADA and IEC 61850)
- Direct serial link (SCADA)

The ERL I/O Expansion unit offers communications interfaces on both the front and rear panel of the IED. The front panel provides one USB Standard-B receptacle (Port 450) and one 100BASE-T Ethernet connection port (Port 401) available for unit communications. The device rear panel provides additional Ethernet connection ports (Ports 401/402) and DB-9 serial ports that provide direct access to the unit's interface and SCADA services. Port availability will vary based on selected model configuration parameters.

4.5 Ethernet LAN Link

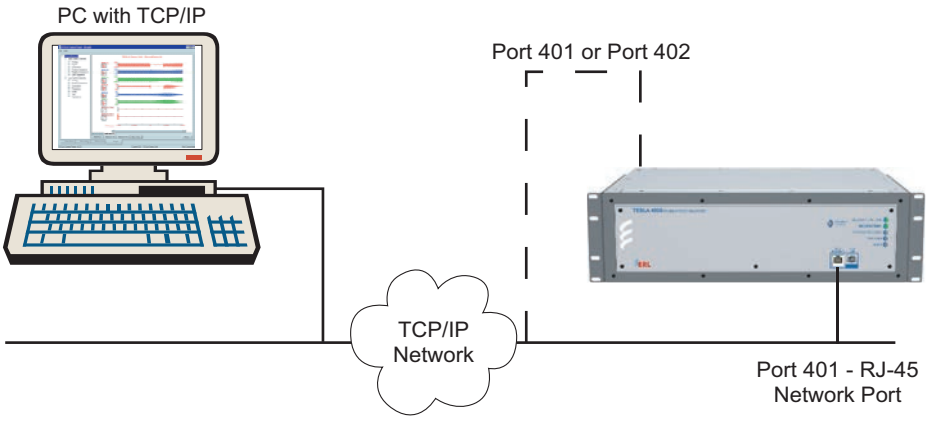


Figure 4.1: Ethernet LAN Link

You can access the device's user interface, DNP3 SCADA and IEC 61850 services simultaneously with the Ethernet TCP/IP LAN link through the network ports. The rear Port 401 and 402 are either 100BASE-T copper interface with an RJ-45 connector or 100BASE-FX optical interface with an ST style connector. Rear Panel port 401 and port 402 are factory configurable as a copper or optical interface. The front Port 401 is 100BASE-T copper interface with an RJ-45 connector.

Connect to the Ethernet LAN using a cross over cable with an RJ-45 connector or 100BASE-FX 1300 nm, multimode optical fiber with an ST style connector.

By default, the Port 401 is assigned with an IP address of 192.168.100.80. Port 402 is assigned with an IP address of 192.168.101.80. If this address is not suitable, it may be modified using the recorder's Maintenance Menu, see "Maintenance Menu and Error Handling" on page 12-1.

Modify the Default Gateway and Network Mask if necessary.

- The Default Gateway may need to be changed if the recorder and the control panel (or RecordBase) are on different but connected networks. The default setting is No Default Gateway.
- The Network Mask may need to be changed if the recorder and control panel are on different subnets. The default setting is 255.255.255.0
- To modify the Default Gateway or Network Mask use the maintenance Menu command 1- 3 IP address
- If unsure of these setting contact your network administrator

TESLA Control Panel Setup

1. Ensure that the computer running TESLA Control Panel has access to the Ethernet network to which the unit has been connected.
2. Start TESLA Control Panel.

3. Choose the target unit from the *Select IED* list in TESLA Control Panel's Main Menu.
   - If there is not already an entry for this unit, create one using the *Add New* button

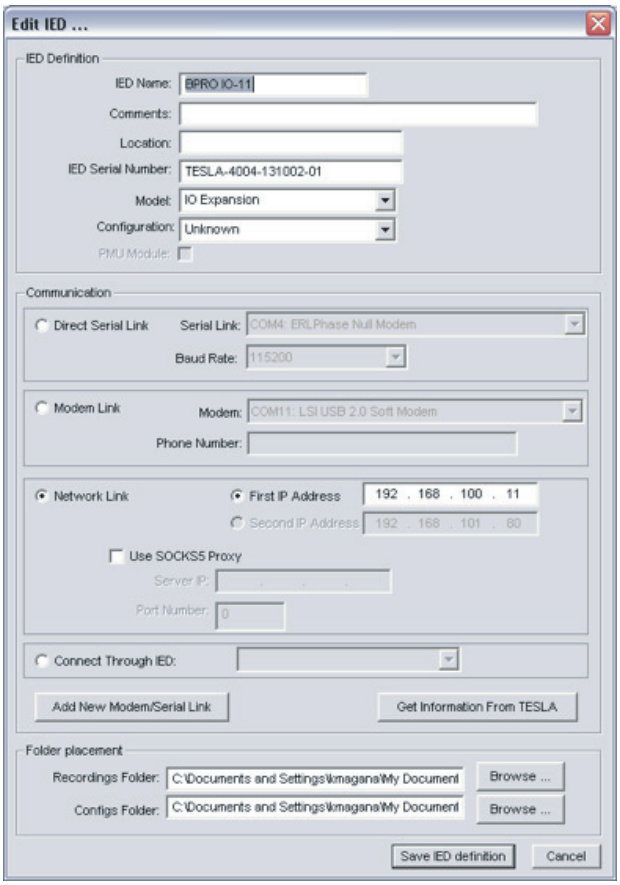


Figure 4.2: Edit IED

   - The method of communication with the unit is specified as part of its IED definition. Use the *Edit* button to view or change this information. Ensure the *Network Link* option is selected and the unit's IP address is entered.
   - For details on IED definitions see "Working with TESLA Control Panel" on page 5-1.

4. Initiate the connection by selecting the *Connect* button.
   - A dialog box will appear to show connection progress.
   - The connection state and the current IED you are connected to is shown on the Windows status bar

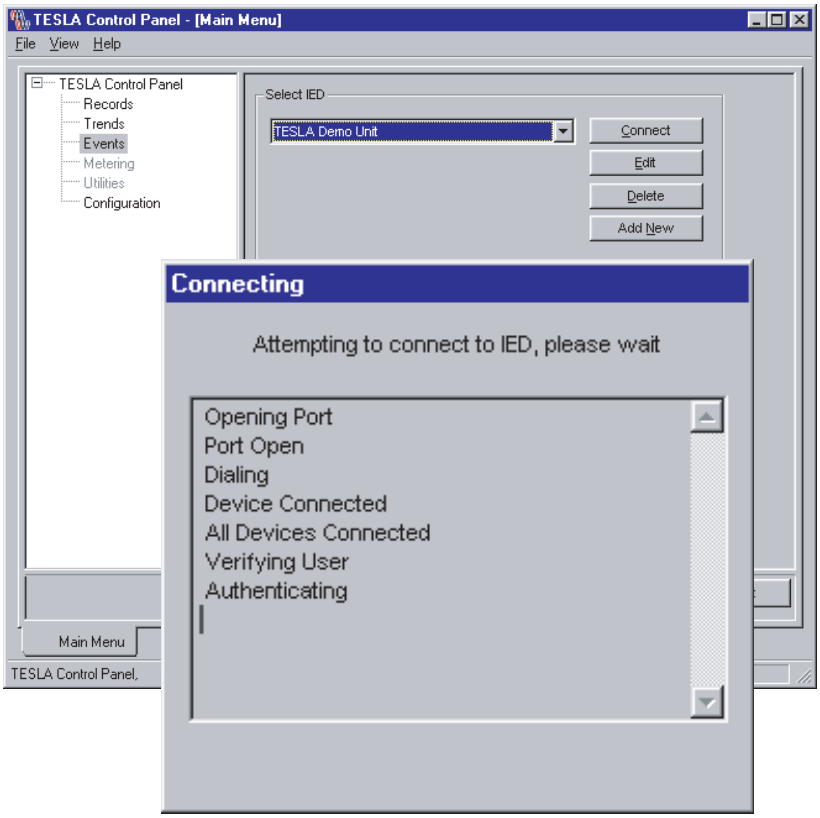


Figure 4.3: Connect Button Dialog Box

4.6 USB Link

Your PC must be appropriately configured for USB communication (see “TESLA Control Panel Installation” on page 3-1).

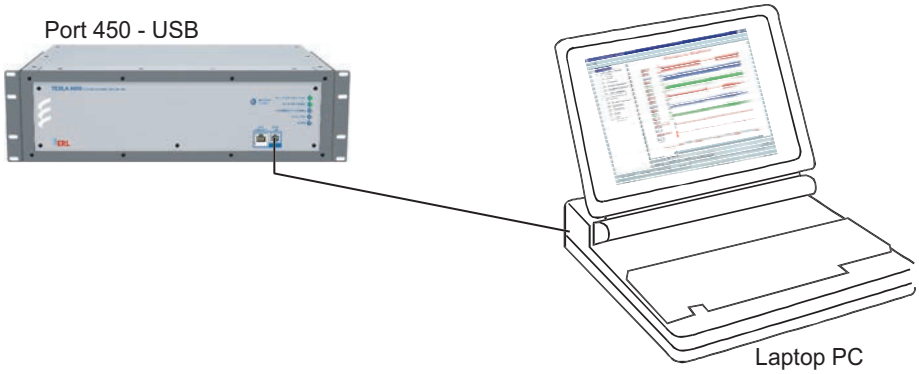


Figure 4.4: USB Link

To create an USB link between the IED and the computer, first the USB driver for the ERLPhase 4000 Series Device needs to be installed, as follows:

Unzip the file (can be obtained from ERL web site):

ERLPhase_USB_driver.zip

In this case we assume you unzipped to the Desktop.

In Windows XP or Windows 7

Connect a USB port of the PC to Port 450 (USB front) of the IED. The IED was already powered on.

In the window

“Welcome to the Found New Hardware Wizard”

“Can Windows connect to Windows Update to search for software?”

Check the option “No, not this time”

In the window

“This wizard helps you install software for:”

ERLPhase 4000 Series Device

“What do you want the wizard to do?”

Check the option “Install from a list or specific location (Advanced)”

In the window

“Please choose your search and installation options”

“Search for the best driver in these locations”

Uncheck the option “Search removable media (floppy, CD-ROM.)”
Check the option “Include this location in the search”
Browse for the following folder:

C:\WINDOWS\tiinst\TUSB3410

In the window

"Hardware Installation"

"The software you are installing for this hardware"

"ERLPhase 4000 Series Device"

"has not passed Windows Logo testing to verify its compatibility with Windows XP" or "Windows can't verify the publisher"

Hit *Continue Anyway*

In the window

"Completing the Found New Hardware Wizard"

"The wizard has finished installing the software for"

"ERLPhase 4000 Series Device"

Hit *Finish*

To verify the installation was successful, and to which comm port is the ERL-Phase 4000 Series Device configured, do the following:

In Windows XP go to

Start>Control Panel>Performance and Maintenance>System>Hardware>Device Manager>Ports

or (if using Control Panel's Classic View)

Start>Control Panel>System>Hardware>Device Manager>Ports

In Windows 7 'small icons' view, go to

Start>Control Panel>Device Manager>Ports

Look for the port number associated to this device."ERLPhase 4000 Series Device"

Look for a COM#, where "#" can be 1, 2, 3, etc. Leave the default settings for this port.

It is recommended to restart the PC after the USB driver installation.

The default baud rate for the recorder USB Port 450 is 115200, however to double check it login to the recorder display and go to:

Main Menu> System> Recorder Comm Setup

To establish a USB link between the unit and your computer, connect your computer's USB port and Port 450 on the unit's front panel. Use a standard USB peripheral cable.

1. Ensure the unit port and your PC's port have the same baud rate and communication parameters.
   - The unit's USB port appears as a serial port to the PC and is fixed at 8 data bits, no parity and 1 stop bit and has a default baud rates of 115,200 bauds.

- The baud rate and communication parameters of your computer's USB port is set automatically by TESLA Control Panel *(Edit IED>Communication>Direct Serial Link*)

2. Choose the target unit from the *Select IED* list in TESLA Control Panel's Main Menu.
   - If there is not already an entry for this unit, create one using the *Add New* button.
   - The method of communication with the unit is specified as part of its IED definition. Use the *Edit* button to view or change this information. Ensure the *Direct Serial Link* option is selected.
   - For details on IED definitions see "Working with TESLA Control Panel" on page 5-1.
3. Initiate the connection by selecting the *Connect* button.
   - A dialog box will appear to show connection progress.
   - The connection state and the current IED you are connected to is shown on the Windows status bar at the bottom of the screen.

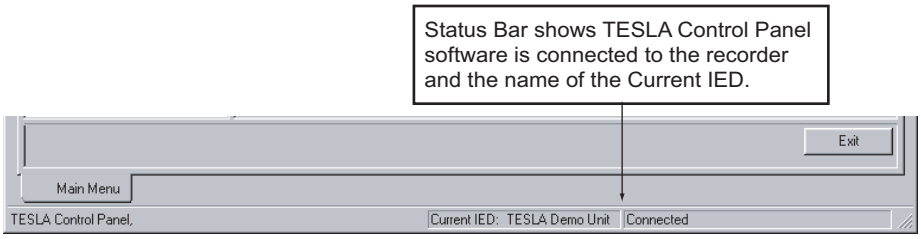

Status Bar shows TESLA Control Panel software is connected to the recorder and the name of the Current IED.
Exit
Main Menu
TESLA Control Panel,
Current IED: TESLA Demo Unit
Connected

Figure 4.5: Status Bar

If the connection fails, check the following:

- The communication parameters are the same on both ends (see Step 1 above).
- The correct serial port has been selected on your computer.

4.7 Direct Serial Link

Your PC must be appropriately configured for serial communication (see “TESLA Control Panel Installation” on page 3-1) and Port 405 must be available on the IED to enable a direct serial link.

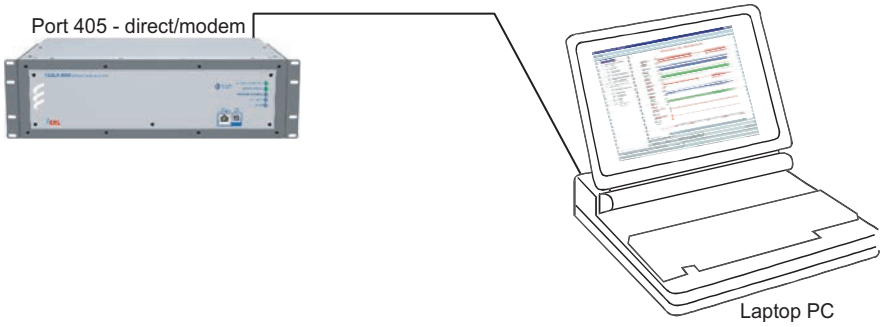


Figure 4.6: Direct Serial Link

To create a serial link between the device and your computer, connect your computer’s serial port and Port 405 on the unit’s rear panel.

The serial ports are configured as EIR RS-232 Data Communications Equipment (DCE) devices with female DB9 connectors. This allows them to be connected directly to a PC serial port with standard straight-through male-to-female serial cable, for pin-out for details see Communication Port Details on page 4-14. Rear Port 405 is for SCADA.

1. Ensure the device port and your PC’s port have the same baud rate and communication parameters.
   - Port 405 is fixed at 8 data bits, no parity and 1 stop bit and has a default baud rates of 38,400 bauds.
   - The baud rate and communication parameters of your computer's USB port is set automatically by TESLA Control Panel *(Edit IED>Communication>Direct Serial Link*)
2. Choose the target device from the *Select IED* list in TESLA Control Panel’s Main Menu.
   - If there is not already an entry for this device, create one using the *Add New* button.
   - The method of communication with the device is specified as part of its IED definition. Use the *Edit* button to view or change this information. Ensure the *Direct Serial Link* option is selected.
   - For details on IED definitions see “Working with TESLA Control Panel” on page 5-1.
3. Initiate the connection by selecting the *Connect* button.
   - A dialog box will appear to show connection progress.

- The connection state and the current IED you are connected to is shown on the Windows status bar at the bottom of the screen.

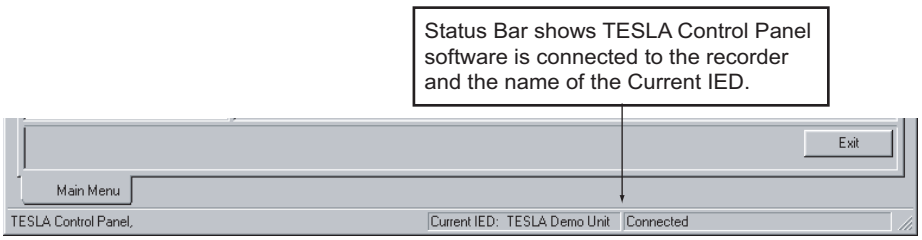

Status Bar shows TESLA Control Panel software is connected to the recorder and the name of the Current IED.
Exit
Main Menu
TESLA Control Panel,
Current IED: TESLA Demo Unit
Connected

Figure 4.7: Status Bar

Some newer laptop computers do not have serial ports. A USB serial converter adapter can provide a surrogate serial port for a direct connection to the device. The Edgeport USB Serial Adapter, model # Edgeport/1, from B&B Electronics (www.bbelec.com) is an example of such a device.

4.8 Accessing SCADA Services

The device supports DNP3 (Level 2) and Modbus SCADA protocols as standard features. This section describes how to connect and configure the services. Protocol details, including point lists, are provided in the appendices.

Serial Port Connection

Both DNP3 and Modbus protocols are available on the device's serial Port 405, an RS-232 DCE port with a female DB9 connector. The port is wired to support a connection to a PC serial port (or equivalent) using a standard straight-through male to female serial cable. An external RS-232 to RS-485 converter can be used to connect to an RS-485 network. For port pin-out and cabling information see "Communication Port Details" on page 4-20.

Ethernet Connection

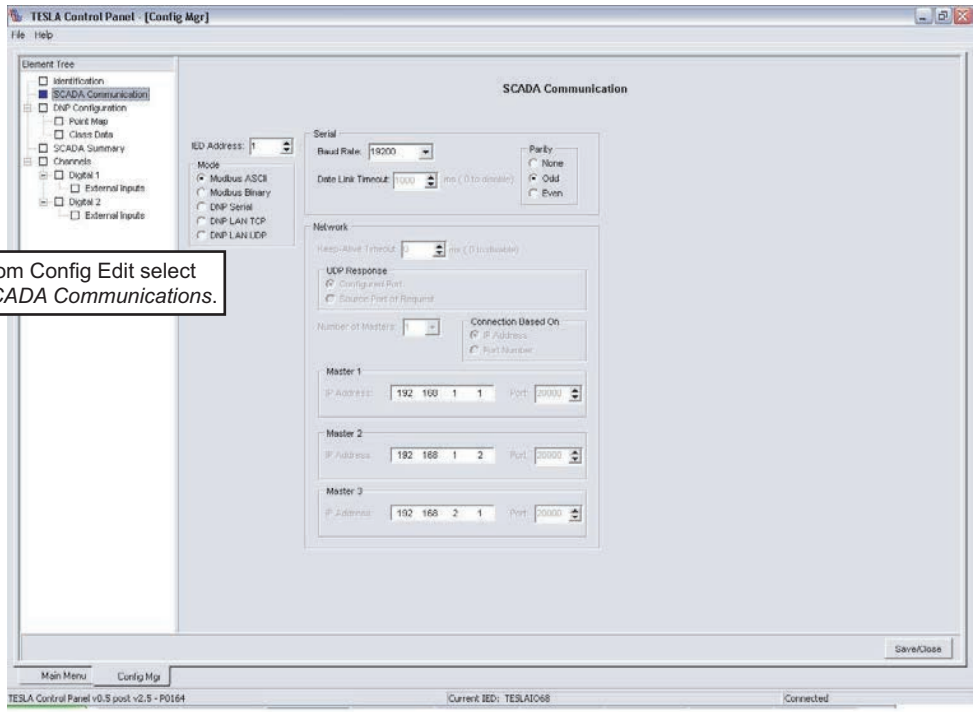
The DNP protocol can also be available over Ethernet using TCP or UDP. A standard 100BASE-T Ethernet cable is required.

The Ethernet port can support DNP SCADA and user interface access via TESLA Control Panel at the same time.

For details on setting the recorder's IP address, "Maintenance Menu and Error Handling" on page 12-1.

Protocol Settings

Configuration of the SCADA protocol and communication parameters is done through the SCADA Configuration section of the device setting file. Setting descriptions follow.



From Config Edit select *SCADA Communications*.

Figure 4.8: SCADA Protocol Settings

Table 4.2: SCADA Protocol Settings Mode	
Mode	Select one of the available SCADA modes.
Baud Rate	Port 405 serial baud rate. Default is 19,200.
Parity	Port 405 serial parity. Note: When parity is set to None and a Modbus protocol is selected, the number of stop bits automatically is set to 2, as per the Modbus standard.
Stop Bits	(Automatic setting). Always set to 1 stop bit except as noted in Parity setting above.
Data Bits	(Automatic setting) The number of data bits is controlled by the selected protocol mode. Modbus ASCII:7 data bits Modbus RTU:8 data bits DNP 3:8 data bits
Slave Address	Identifies the unit to the SCADA master.

Table 4.2: SCADA Protocol Settings Mode	
Datalink Timeout	(DNP) Specifies the time in which the recorder expects a response from the SCADA master to primary frame messages. If a response is not received in this time, the recorder will re-transmit the message. The timeout is usually set to 0 milliseconds per DNP3 Technical Bulletin 9804-002. This document is available from the DNP3 User's Group (www.dnp.org) For UDP and TCP modes, the timeout is not settable and is automatically set to 0 milliseconds.
Master IP Address (DNP LAN TCP or DNP LAN UDP)	Defines the IP addresses of the master SCADA devices that will be polling the IO Expansion. This prevents unauthorized master devices from communicating with the IO Expansion. Note: These settings do not control IP address of the TESLA's Ethernet card. That is done through the recorder's Maintenance Menu. Make sure the Master IP Addresses are different from the TESLA IP Address.
Port	DNP (TCP or UDP) Defines the TCP or UDP port on which the DNP service may be accessed. Usually set to 20000.

SCADA Point Mapping

Modbus Protocol

The data points available for Modbus SCADA interface are fixed and are not selectable by the user.

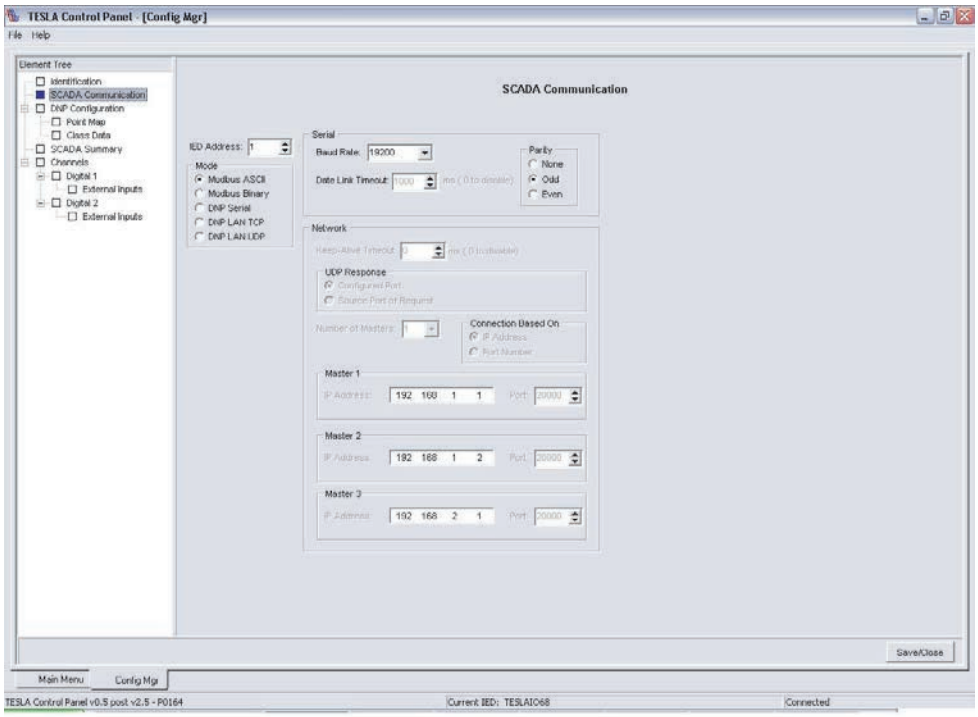


Figure 4.9: Communications Setup In Control Panel for Modbus

DNP Protocol

The device supports a DNP3 (serial) SCADA connection. DNP3 is available via a direct serial link or an Ethernet LAN connection using either TCP or UDP.

Serial DNP communications can be utilized exclusively via serial Comm Port 405. Comm Port 405 is an RS232 DCE DB9F port located on the back of the device. An external RS-232 to RS-485 converter can be used to connect the device to an RS-485 network.

Network DNP communications can be utilized via physical LAN provisions . DNP communications can be used with multiple masters when it is utilized with TCP.

The data points available for DNP SCADA interface are selectable by the user through the DNP Configuration section of the device settings; point selection is done through the Point Map configuration; class assignments for selected points are done through the Class Data configuration. Complete details regarding the DNP3 protocol emulation and data point lists can be found in DNP3 Device Profile on “DNP3 Device Profile” on page Appendix E-1.

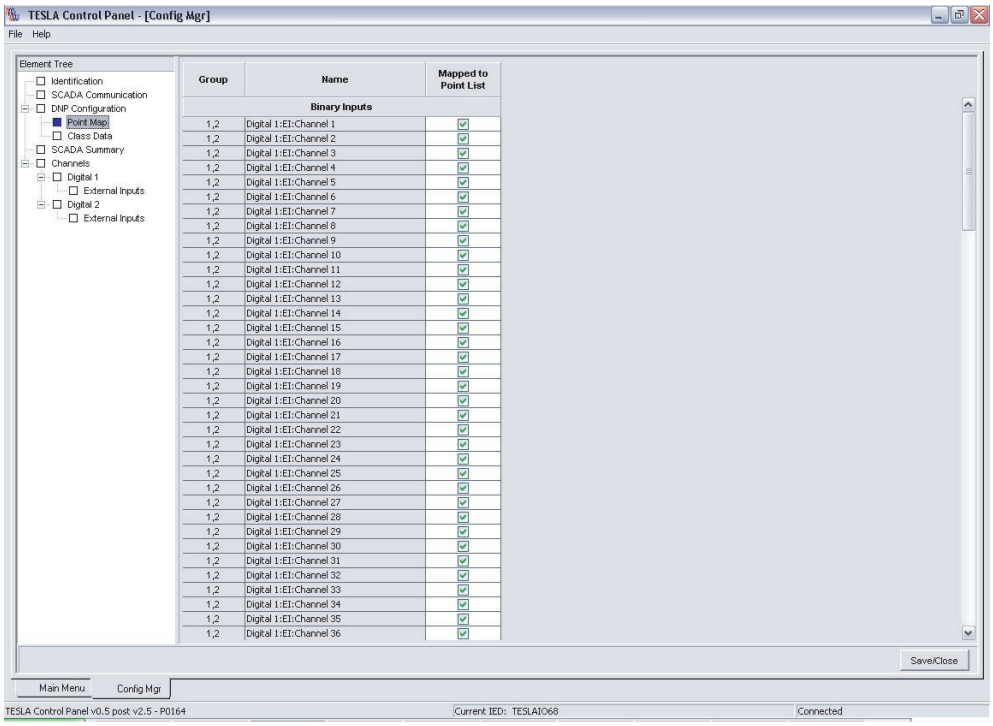


Figure 4.10a: DNP_point_map

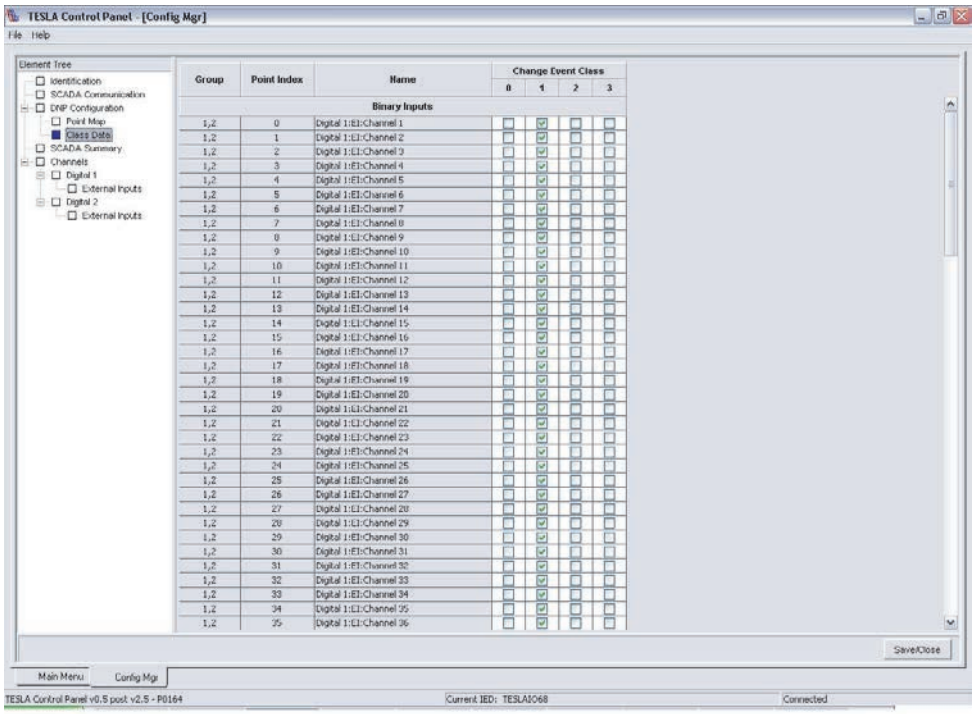


Figure 4.10b: DNP_class_data

Diagnostics

Protocol monitor utilities are available to assist in resolving SCADA communication difficulties such as incompatible baud rate or addressing. The utilities can be accessed through the Maintenance user interface, “Maintenance Menu and Error Handling” on page 12-1.

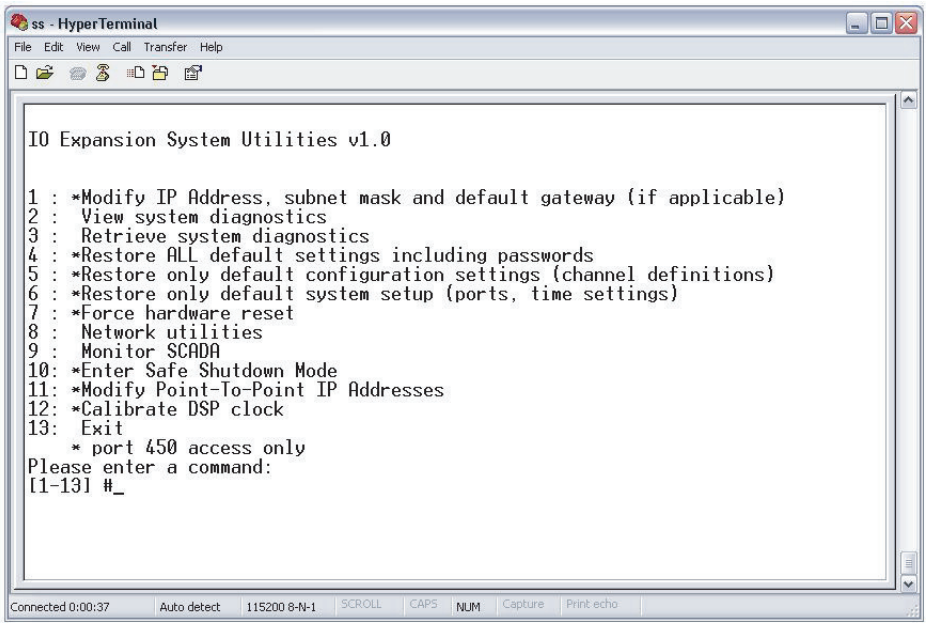

ss - HyperTerminal
File Edit View Call Transfer Help
IO Expansion System Utilities v1.0
1 : *Modify IP Address, subnet mask and default gateway (if applicable)
2 : View system diagnostics
3 : Retrieve system diagnostics
4 : *Restore ALL default settings including passwords
5 : *Restore only default configuration settings (channel definitions)
6 : *Restore only default system setup (ports, time settings)
7 : *Force hardware reset
8 : Network utilities
9 : Monitor SCADA
10: *Enter Safe Shutdown Mode
11: *Modify Point-To-Point IP Addresses
12: *Calibrate DSP clock
13: Exit
* port 450 access only
Please enter a command:
[1-13] #_
Connected 0:00:37
Auto detect
115200 8-N-1
SCROLL
CAPS
NUM
Capture
Print echo

Figure 4.11: HyperTerminal

4.9 Communication Port Details

The serial port 405 is configured as EIA RS-232 DCE device with female DB9 connectors. This allows them to be connected directly to a PC serial port with a standard straight-through male-to-female serial cable.

The ERL Digital I/O Expansion Module (v1.0 or higher) has been factory configured to communicate to peripheral software tools and devices using the ERLPhase registered IANA Port 7631.

Table 4.3: Device Serial Port

Port	Location	Function
405	Rear Panel	Connection to SCADA (DNP3 or Modbus) interface. Default baud rate set at 19,200 baud.

Table 4.4: Signal connections to pins on Device Port

Signal Name	Direction PC<->IED	Pin # on the IED Port
DCD	←	1
RxD	←	2
TxD	→	3
DTR	→	4
Common		5
DSR	←	6
RTS	→	7
CTS	←	8
No connection		9

Notes:
IED is DCE, PC is DTE.
Pins 1 and 6 are tied together internal to the IED.

Table 4.5: Cable Pin Connections

Male DB-9 Cable End for IED Port	Female DB-9 Cable End for Computer Port
Pin # on Cable	Pin # on Cable
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

Table 4.6: Port Assignments

7631* *Factory default	Listening ports on IO Expansion. TESLA Control Panel connection ports. Configurable through Maintenance Menu.
23	Telnet
20000/TCP or UDP	Default DNP3 can be modified by the user.

5 Working with TESLA Control Panel

5.1 Device Workspace

TESLA Control Panel supports multiple devices and devices. Each device has its own workspace within Control Panel that stores its communications parameters, records and configuration files.

A separate workspace should be created for each device on your system to store its configuration files and records.

When first installed, TESLA Control Panel includes a workspace for a recorder called TESLA 4000 Demo Unit. It contains sample records and configuration files and is configured for network connection with an evaluation unit.

Selecting a Device Workspace

To work with a particular device, select it from the *Select IED* box on the *Main Menu* tab. If you are already connected to an IED you will not be able to select a different IED until you disconnect.

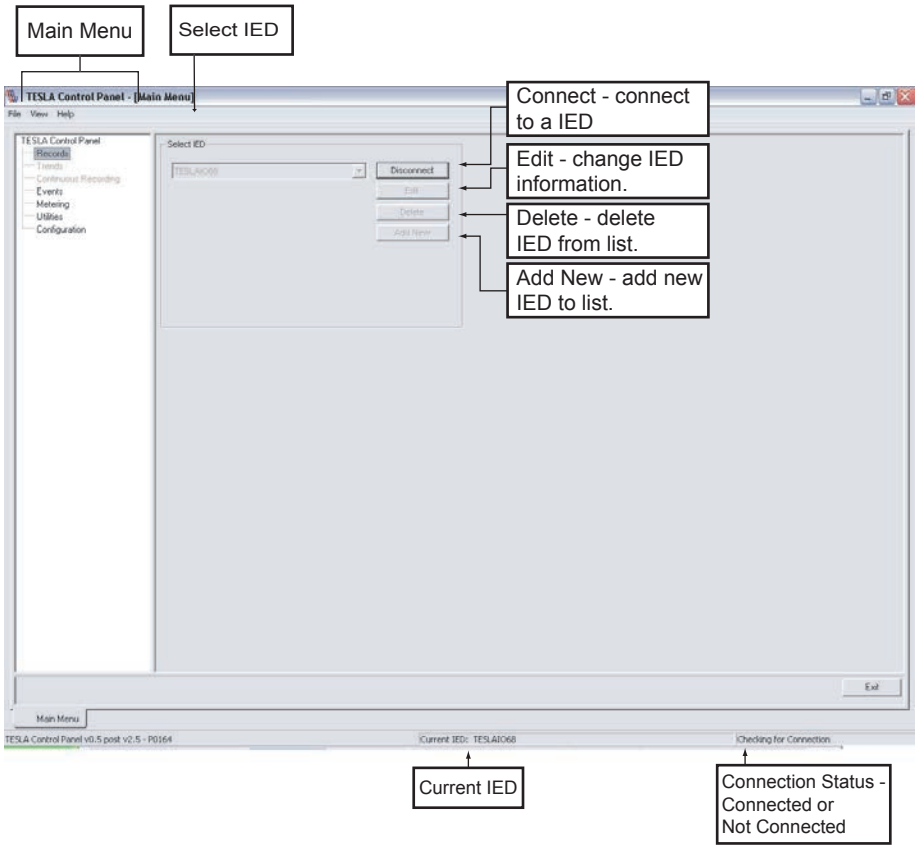

Main Menu
Select IED
Connect - connect to a IED
Edit - change IED information.
Delete - delete IED from list.
Add New - add new IED to list.
Current IED
Connection Status - Connected or Not Connected

Figure 5.1: Selecting a Device Workspace

Current IED

Selecting a device sets TESLA Control Panel's focus to that device's workspace, known as the Current IED. The records and configuration files belong to the selected device.

If you initiate a connection using TESLA Control Panel, it connects to the current IED using the communication parameters specified for this IED.

> The name of the Current IED is always displayed in the Status Bar at the bottom of the TESLA Control Panel window (for details see Figure 5.1: Selecting a Device Workspace on page 5-1).

TESLA Control Panel assumes that the device it is communicating with is the one identified as the Current IED. Forcing a connection with a different device (i.e. moving the serial cable without telling Control Panel to disconnect), can cause the records and configuration files of that device to be mixed with those of the Current IED.

5.2 Adding/Editing a Device Workspace Definition

Device workspaces are added, modified or deleted from the TESLA Control Panel Main Menu using controls in the *Select IED* dialog box (for details see Figure 5.1: Selecting a Device Workspace on page 5-1) The *Edit* button displays the selected device's definition screen. The *Add New* button is used to create a new device definition. The *IED* definition is shown in Figure 5.2: Device Workspace Definition and the settings are described in the following table.

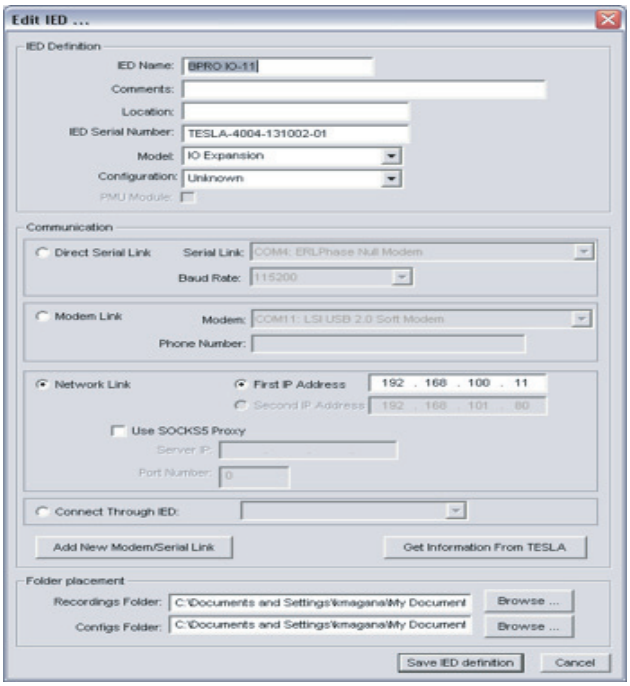


Figure 5.2: Device Workspace Definition

Table 5.1: IED Workspace Settings

IED Definition	
IED Name	The IED Name is the name you assign to this device's workspace. It appears in the IED selection and the Current IED display at the bottom of the TESLA Control Panel window. We recommend that you use the same name for this workspace as the Unit Name given to the device ("Unit Identification" on page 7-2).
Comments	User-defined, for your reference only.
Location	User-defined, for your reference only.
IED Serial Number	Enter the IED Serial Number to match the serial number of the actual device.

Table 5.1: IED Workspace Settings	
Get Information from IED	Connects to the device and retrieves its configured name, location and serial number. The corresponding fields in the IED Definitions are overwritten.
Configuration	
IP Address	IP addresses of the device. The device's default factory IP addresses are 192.168.100.80 and 192.168.101.80. It is changed through the device's Maintenance Menu.
Communication	
Network Link	Connect to this device via a TCP/IP network.
Folder Placement	The Default Folder directory applied to new IED definitions can be modified with the *File>Data Locations* command from the Main Menu.
Recordings Folder	The directory where the IED's retrieved records are stored.
Configs Folder	The directory where the IED's configuration files are saved.

You can share configuration files and records with other TESLA Control Panel users by using common folders

5.3 Online and Offline Operation

TESLA Control Panel can be used with or without a connection to the selected device. Both offline and online modes work within the selected Current IED workspace.

Offline (Not Connected)

In Offline mode, you can manage and display a device's local (previously uploaded) records and create and edit configuration files without being connected to the unit.

Online (Connected)

In Online mode you are connected to the device and have access to both local and remote data and functions:

- Records (both local and on the device)
- Event log
- Metering (realtime readings of input and calculated channels)
- Channel and trigger configurations (the one presently active in the device and any saved ones you may have created)
- Setup utilities and record configuration screens
- Record graphics display

Connection Status

The Status Bar at the bottom right side of the TESLA Control Panel window shows if you are presently online or offline.

5.4 Navigating in TESLA Control Panel

TESLA Control Panel uses a split screen format. The left pane is used for navigation or selection. The right pane is the working area for each of the program's main sections. To bring up the Control Tabs, shown below, you must select the appropriate item on the Navigation Tree by double-clicking. Devices supported within TESLA Control Panel may not utilize all of the features shown.

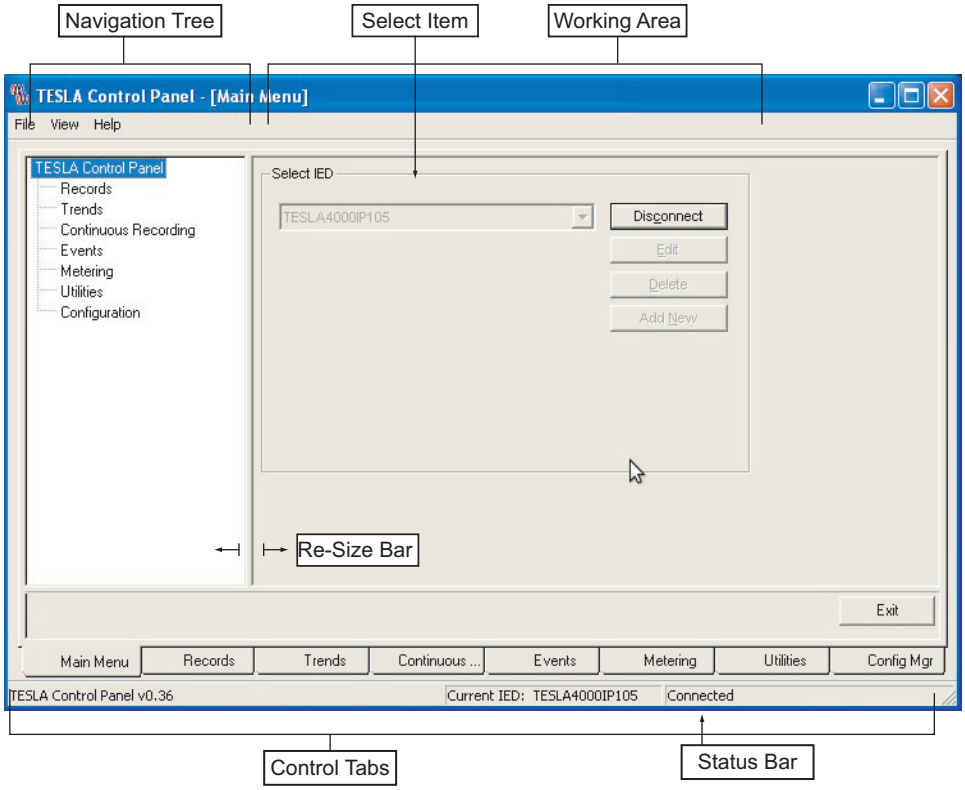


Figure 5.3: TESLA Control Panel Display Sections Navigation Tree

The left pane provides a means of moving between TESLA Control Panel functions or selecting items within a function (e.g. channels from a record). TESLA Control Panel functions—Records, Events, Metering, Utilities and Configuration are activated by a double-click. (as applicable).

You can optimize the screen space between the tree and the working area to create a larger working area. Some screens have a *Hide Tree* button to maximize the working area.

Working Area

The Working Area on the right pane of the display represents the main working area of each section of the TESLA Control Panel.

Control Tabs

The Control Tabs are a row of selection tabs near the bottom of the screen. Each time you start a function, a corresponding tab is created.

Select the control tabs to navigate from one screen to another or the *Main Menu* item. Use the *Close* button to close the screen.

Status Bar

The Status Bar at the bottom of the TESLA Control Panel displays the name of the selected device workspace and the status of the connections.

6 Metering Display

The device has a full set of real-time metering displays that provide present readings from the digital input channels and the alarm contact status.

The Metering display is accessed through the *Metering* item in the *Main Menu* tab's function list.

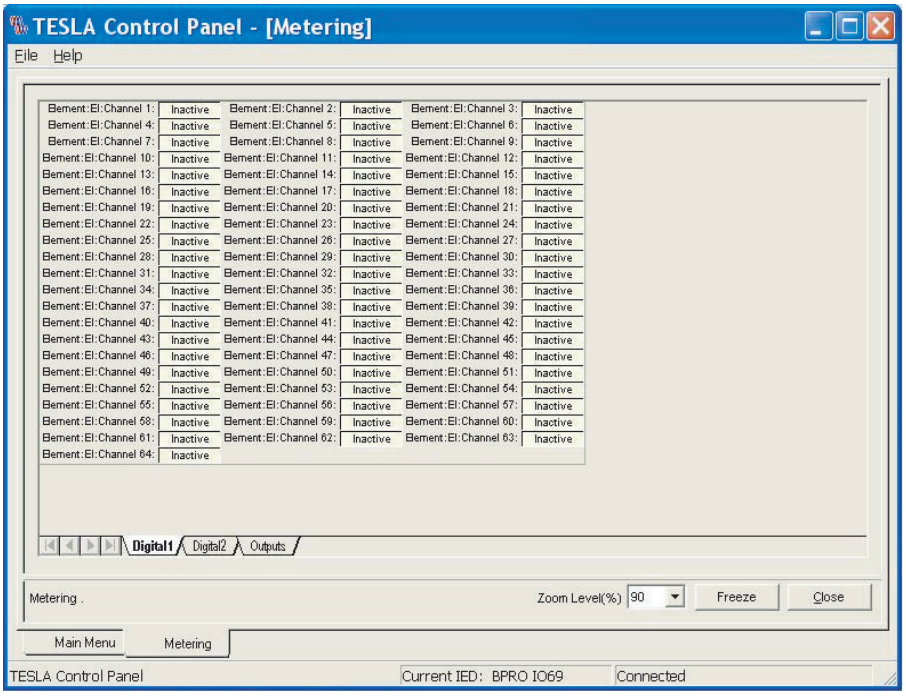


Figure 6.1: Metering Display

Standard Metering Screens

The Metering display provides tabs at the bottom to select among multiple display screens. The first two tabs, *Digital1* and *Digital2* display the real-time status of all independent 128 digital external inputs. The remaining tab, *Outputs*, provide an indication of alarm contact status.

Display Zoom

The magnification of metering screens can be adjusted using the *Zoom Level* (%) control. This allows the display to be enlarged for easy viewing while commissioning or testing.

Freeze

The *Freeze* button provides a way to temporarily stop the update of the display. It can be used to ensure a synchronized set of readings for documentation purposes. The metering display can be exported to another program using Windows built-in Alt PrintScreen key and standard paste functions.

7 IED Setup Utilities

The ERL I/O Expansion has global setup parameters that establish its identity and define its operation. Setup parameters define:

- Unit identification
- Communication port parameters
- Record length and mode settings
- Time display and settings
- Passwords

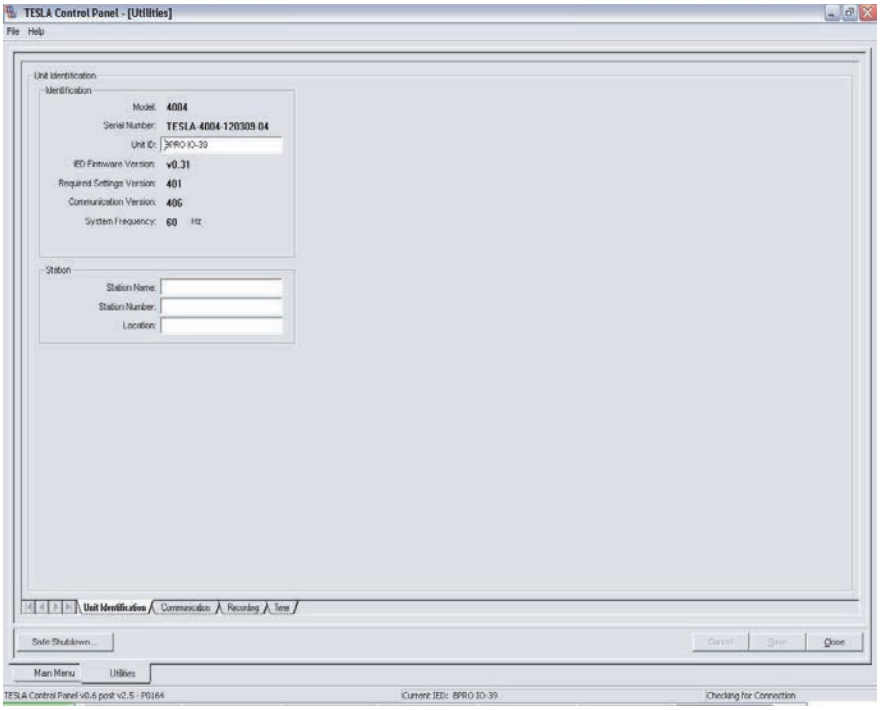


Figure 7.1: Recorder Setup Utilities

The setup parameters are accessed through the *Utilities* tab on TESLA Control Panel. You must be communicating with the IED for the *Utilities* tab to be available.

For details on connecting to the device using TESLA Control Panel software see “Communicating with the ERL I/O IED” on page 4-1.

7.1 Unit Identification

The Unit Identification tab identifies a particular recorder and its records. Double-click *Utilities* to bring up the tabs; select *Unit Identification*.

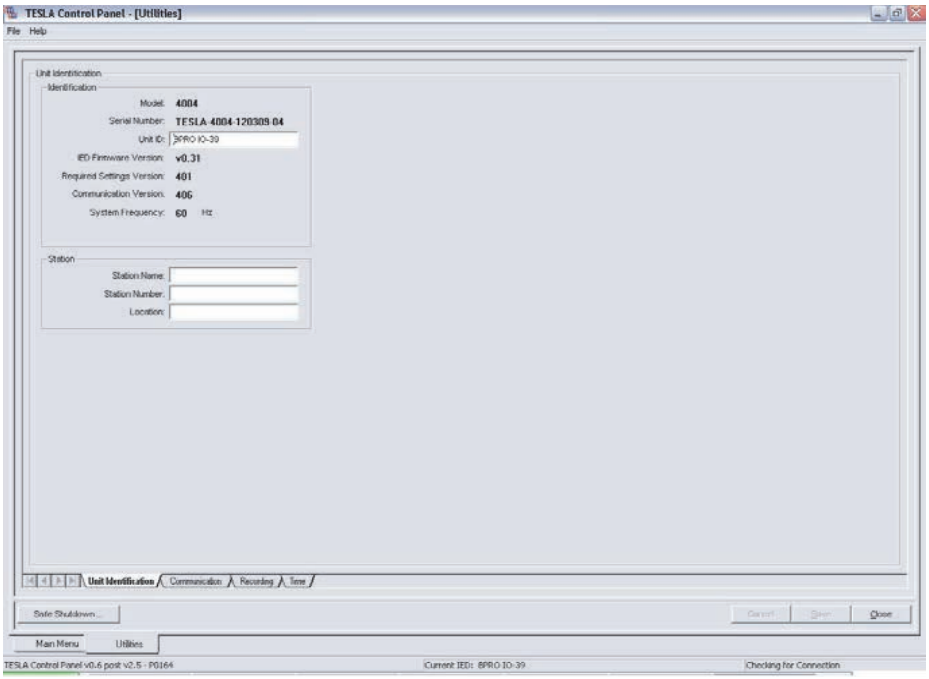


Figure 7.2: Device Setup Utilities - Unit Identification

Table 7.1: Unit Identification Settings	
Identification	
Serial Number	Read-only field, displays the serial number of the IED unit currently connected.
Unit ID	User-entered field that identifies the unit. It is part of the name given to records produced by the unit to identify their origin. By convention, this name should be the same as the "IED Name" assigned to the device and device's workspace. The name must not contain the following: ", " "/" "\" ":" or any other character not valid for a Windows file name.
IED Firmware Version	Read-only field that displays the firmware version of the currently connected IED unit.
Required Settings Version	Describes the version of the settings file required by the connected device. Control Panel is capable of creating older versions of settings files for use with devices operating legacy firmware.
Communication Version	Read-only field that displays the version of the communications protocol used by the currently connected IED.
System Frequency	Read-only field that displays the assumed power system frequency of the device. This is a factory setting.

Table 7.1: Unit Identification Settings	
Station	
Station Name	User-defined, for your reference only.
Station Number	User-defined, for your reference only.
Location	User-defined, for your reference only.

7.2 Communication Port Settings

The Communication settings control the modes and baud rates of the device's communication ports.

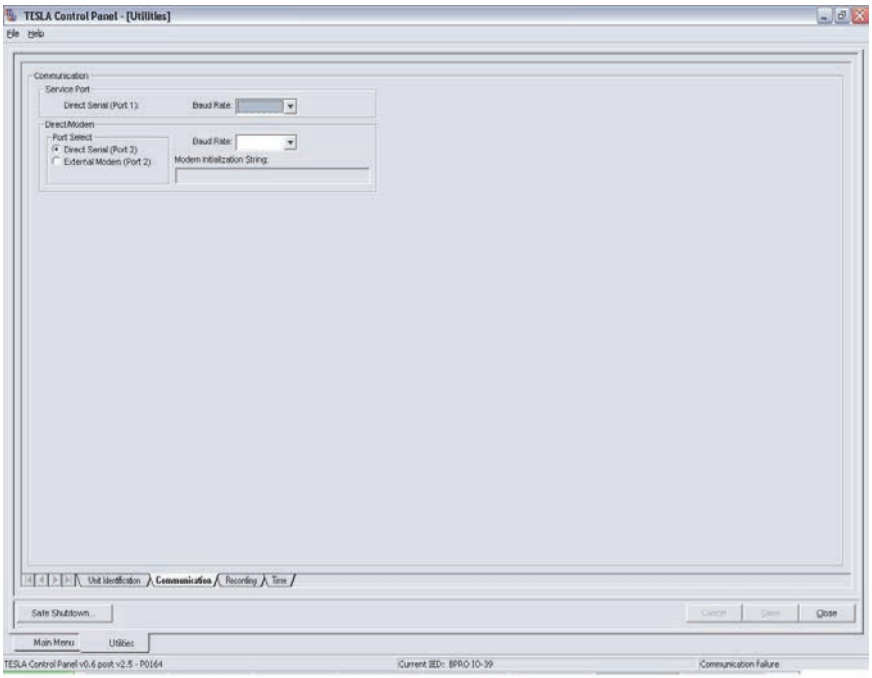


Figure 7.3: IED Setup Utilities - Communication Ports

Table 7.2: Communication Settings	
Service Port	
The Service Port is Port 450 on the front of the device. It can be used for connection with TESLA Control Panel or a terminal program (to access the Maintenance Menu).	
Baud Rate	Sets the baud rate of the port. The default baud rate is 115,200 N81 baud. Note: The baud rate must match that of the port of the computer connected to this port. For best results, use the maximum baud rate that your communication link and equipment can sustain.

For details regarding the data and functions available on the IED's SCADA port see "DNP3 Device Profile" on page Appendix E-1.

7.3 Recording Control Settings

The Recording Settings control the parameters of the High Speed Recording.

For High Speed Recording the IED can create up to three records simultaneously. The device employs sophisticated trigger combination algorithms used to combine data from multiple events into a single record and also to reduce the amount of redundant data in the records. In addition, the device will combine data captured using multiple time-frames into a single record.

The IED possesses two modes of capturing data; Edge Recording and Duration Recording. Both are available for High Speed Recording.

Edge Mode

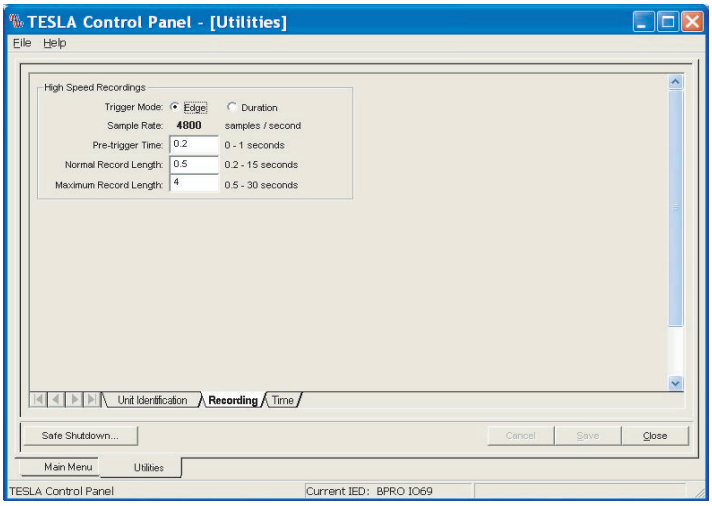

TESLA Control Panel - [Utilities]
File Help
High Speed Recordings
Trigger Mode: Edge Duration
Sample Rate: 4800 samples / second
Pre-trigger Time: 0.2 0 - 1 seconds
Normal Record Length: 0.5 0.2 - 15 seconds
Maximum Record Length: 4 0.5 - 30 seconds
Unit Identification Recording Time
Safe Shutdown...
Cancel Save Close
Main Menu Utilities
TESLA Control Panel
Current IED: BPRO IO69

Figure 7.4: IED Setup Utilities - Edge Recording

In Edge Recording, the rising edge of the trigger is used to create a record that has a set amount of pre-trigger data and a set amount of post-trigger. This is known as a normal length record. If another trigger is processed while the record is being created, the record may be extended to the full normal length of data associated with the new trigger. Multiple extensions can occur up to the Maximum Record Length limit. Records with combined High Speed data can only be extended during the High Speed data capture portion of the record.

Edge Recording mode tends to create smaller records that contain useful fault data around the start of the trigger, but may not capture data for the entire duration of the trigger.

To enable record auto-extension for multiple triggers, the Maximum record Length must be larger than the Normal Record Length.

At least small amount of pre-trigger time is recommended to ensure the triggering event is included in the records.

Duration Mode

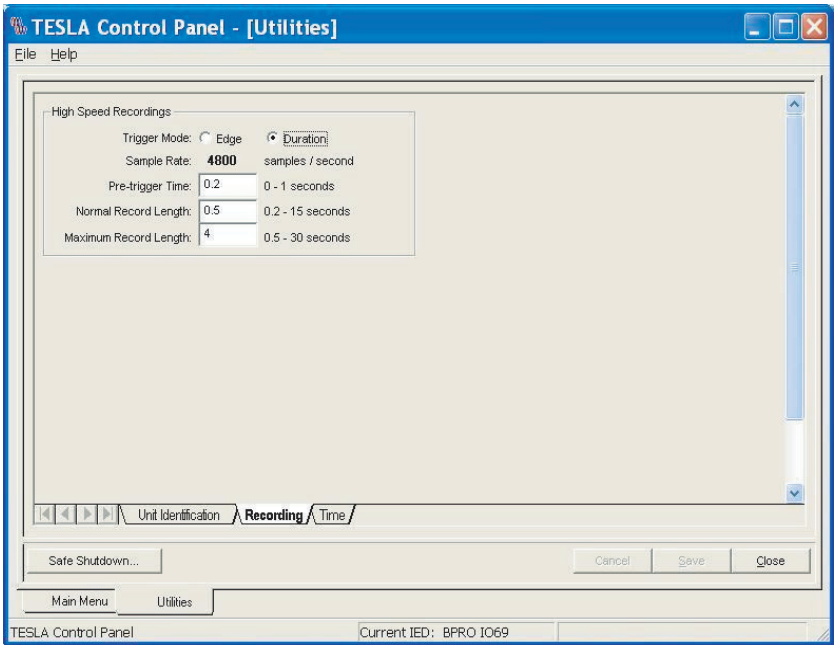

TESLA Control Panel - [Utilities]
File Help
High Speed Recordings
Trigger Mode: Edge Duration
Sample Rate: 4800 samples / second
Pre-trigger Time: 0.2 0 - 1 seconds
Normal Record Length: 0.5 0.2 - 15 seconds
Maximum Record Length: 4 0.5 - 30 seconds
Unit Identification Recording Time
Safe Shutdown...
Cancel Save Close
Main Menu Utilities
TESLA Control Panel
Current IED: BPRO IO69

Figure 7.5: IED Setup Utilities - Duration Recording

In Duration Recording, the duration of the trigger determines the record length. The record stores the configured amount of pre-trigger data, continues to record while the trigger is active and then records a configured amount of post-trigger data. If a trigger remains active, the IED stops recording once the Maximum Record Length limit is reached. If a subsequent trigger occurs while a record is being created, it will be combined with the first trigger using a logical OR operation as long as it is not near to the maximum record length limit. If the trigger is processed near the end of the record, a new overlapping record will be created instead of combining the triggers. Records with combined High Speed can only be combined during the High Speed data capture portion of the record.

Duration Recording mode captures all the data during the fault trigger, but tends to create larger records that may contain unimportant data.

Table 7.3: Recording Settings	
High Speed Recording	
Trigger Mode	Select Edge or Duration mode. See above for descriptions.
Sample Rate	The sample rate is fixed at 96 samples/cycle.
Pre-trigger Time	The length of data that is recorded prior to the trigger time. At least 0.1 seconds of pre-trigger time is recommended to ensure the triggering event is included in the records.
Normal Record Length	Normal Record Length (Edge Mode) is the total length of the record, including pre-trigger data, without any record extension.
Post-Trigger Time	Post Trigger Time (Duration Mode) is the length of data that is captured after the falling edge of trigger event.
Maximum Record Length	Edge Mode: The maximum length of the record including pre-trigger, post-trigger and extensions. To enable record auto-extension for multiple triggers, the Maximum record Length must be larger than the Normal Record. Duration Mode: The maximum length of the record including pre-trigger, trigger and post-trigger.

7.4 Time Display and Settings

The Time Control tab displays the device's current time and provides controls to select and configure the source time signal for the IED, or manually configure the initial time parameters of the system.

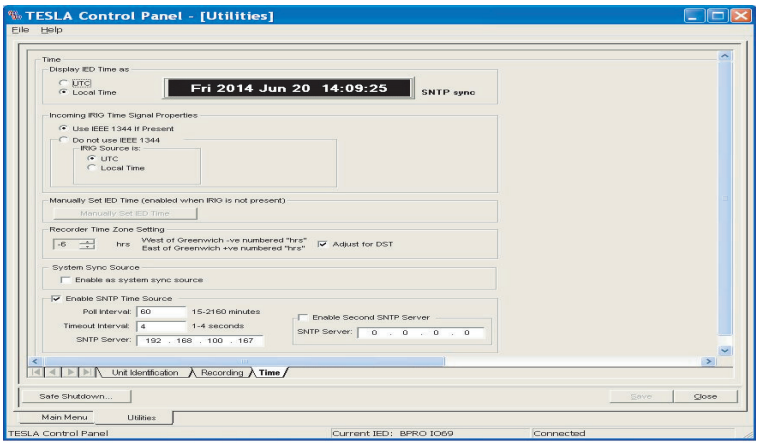


Figure 7.6: IED Setup Utilities - Time Control

Time Sources

The IED uses time as the basis of data recording and requires the presence of a source time signal on the IED. The device supports the use of modulated or unmodulated IRIG-B time signals (external), primary/secondary SNTP network based time synchronization (external) and manually configurable system time based on a free-running, internal oscillator. The internal free-running oscillator is always present on the IED and, in the absence of any external time source, will become the default mode of time synchronization.

An IRIG-B time source will have the highest order of precedence and the highest available time accuracy with an accuracy exceeding 1 µs after calibration. The ongoing presence of a valid IRIG-B time source is indicated by an LED on the front panel of the IED and is evident in data records.

An SNTP time source has a lower order of precedence from a valid IRIG-B source. SNTP operation (primary and secondary) requires network access and the selection and configuration of suitable SNTP network sources. The SNTP time may be configured for re-synchronization cycles ranging from 15 minutes to 36 hours, adjusting the IED system time to an accuracy within +/- 1 second. No visual indication is provided on the IED front panel regarding the status of the SNTP synchronization however this information is available in data records.

The IED comes equipped with an internal free-running oscillator used to generate a 1 PPS time signal in the absence of any alternate available time source. Use of this oscillator as the primary IED time source requires manual time configuration, with the general accuracy subject to user input parameters, and is recommended primarily for stand-alone, unsynchronized applications. The internal oscillator carries a lifetime accuracy (including temperature effects and aging) of +/-25 ppm.

Displayed Time

Time is maintained in UTC format on the device (i.e. without a time zone offset or daylight savings time applied). If the clock feeding the time signal to the device is sending local time, the recorder converts it to UTC internally.

The time displayed in the Time Control screen above is determined by the adjacent time display settings. The IED will automatically convert from its internal UTC time as required. The Time Zone Setting determines the offset between Local time and UTC. DST will automatically add 1 hour to the offset if appropriate.

System Sync Source

Provisions are available on the ERL I/O Expansion Module to acts as a time source for up to five additional IED's or devices. The feature may be enabled or disabled via the TESLA Control Panel application *Time* tab under the *Utilities* section (option only accessible with ERL I/O Expansion units). The IED rear panel Ports 410 - 419 are comprised of a series of 2-wire Time Sync Outputs which provide a IRIG style time output derived fro the IED source clock. Time quality information within the output signal are modified to reflect the derived source.

Event Timestamps

Event timestamps in the device's Event Log are also controlled by the above time display settings. They will be displayed as UTC or local times as configured here.

Record Timestamps

Record timestamps shown in Control Panel's Records tab are converted from UTC using the Windows Time and Date settings of the PC running Control Panel. This enables records from multiple time zones to be normalized to a common time zone and format.

Table 7.4: Time Settings

IED Time is displayed as	
UTC	Sets the time display and the Event Log timestamps to Universal Coordinated Time (UTC). Note that UTC time is not affected by the Time Zone setting or Daylight Savings Time.
Local Time	Sets the time display and the Event Log timestamps to Local Time. Local time is converted to UTC using the Time Zone setting.
Local Time with DST	Same as Local Time, except Daylight Savings Time (DST) is factored into the time conversion. Daylight Savings Time is assumed to be in effect from 2 AM on the first Sunday in April until 2 AM on the last Sunday in October.
Present Time Display	When connected to a device, the device's present time is shown and continually updated. The specified time settings (e.g. Local Time) are applied to the displayed time.

Table 7.4: Time Settings	
Sync/No Sync Display	Indicates that the device synchronization status is to a valid time signal input.
Incoming IRIG Signal Properties	These settings determine how the device responds to IEEE 1344 information in the IRIG-B time signal and manually define the format of the incoming time if IEEE 1344 data is not available.
Use IEEE 1344 If Present	If Use IEEE 1344 if Present is checked and the source clock generates IEEE 1344 data, the device: • Uses the time zone offset from the IEEE 1344 data embedded in the IRIG-B time signal. • Reads the IEEE 1344 data to determine the mode of the incoming IRIG signal (UTC, Local, Local with DST). Otherwise, the device uses the manually entered time zone offset and clock source mode settings.
Do not use IEEE 1344	If Do Not Use IEEE 1344 is selected, the device will ignore any IEEE 1344 data in the IRIG-B signal and use the manually entered time zone offset and clock source mode settings.
IRIG Source	Specifies the mode of the incoming clock signal. Ignored if IEEE 1344 data is present in the IRIG-B time signal and the Use IEEE 1344 If Present setting is enabled.
Manually Set IED Time	Allows the device's clock to be manually set if an IRIG-B signal is not present. If an IRIG-B signal is present, but does not contain IEEE 1344 data, the year can be set manually.
Time Zone Setting	Provides the offset from local time to UTC in hours. For example, Central Time has a +6 hour offset from UTC. This setting is ignored if IEEE 1344 data is present in the IRIG-B time signal and the Use IEEE 1344 If Present setting is enabled.
SNTP Time Source Enable	Activates the IED to attempt SNTP time synchronization based on the user configuration parameters (primary and secondary) for IED synchronization in the absence of an IRIG-B time source. Default configuration for the 4000 series products is for SNTP capabilities to be disabled upon start-up.
SNTP Poll Interval	User configurable parameter for defining SNTP server synchronization time cycle (primary and secondary).
SNTP Timeout Interval	User configurable time duration to wait for a server response following an attempted SNTP network synchronization before considering the target server lost.
SNTP Server	IP address for network based primary and secondary SNTP servers to be used as IED time sources (if enabled) in the absence of a valid IRIG-B signal.

7.5 Password Protection

Access to various IED functions can be protected through the use of passwords.

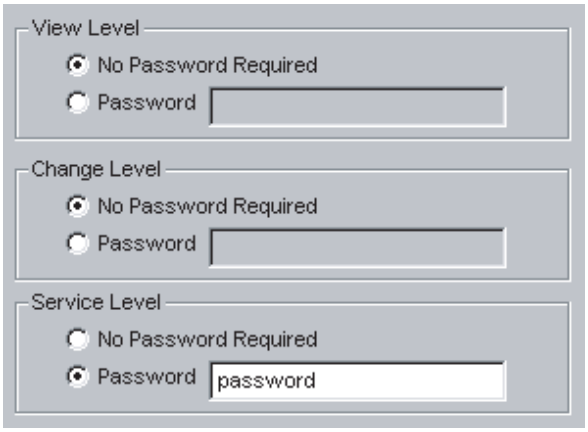


Figure 7.7: Passwords

There are three user access levels: VIEW, CHANGE and SERVICE. The factory default passwords for the three access levels are:

VIEW: view

CHANGE: change

SERVICE: service

Setting Passwords

Passwords can be viewed and set through the *Passwords* tab of TESLA Control Panel's Utilities screen.

You have the option of explicitly disabling the password protection for each access level. Leaving the VIEW access level password disabled, for example, will allow free use of the device for read-only operation.

The Password tab can only be accessed when connected via direct serial link through the device's service port (Port 450). This provides protection from unauthorized remote access while ensuring that on-site staff can freely use the device.

Table 7.5: Setting Passwords

	Function	Required Access Level
Records	Display Record List from IED	VIEW
	Delete Record from IED	CHANGE
	Rename Local Record	None
	Display Local Record List	None
	Delete Local Record	None
Events	Display Event Log	VIEW
	Erase Event Log	CHANGE
Metering	Metering Display	VIEW
Utilities	Display Unit Identification	VIEW
	Set Unit Identification	CHANGE
	Display Communication Settings	VIEW
	Set Communication Settings	CHANGE
	Display Recording Settings	VIEW
	Set Recording Settings	CHANGE
	Display Time & Settings	VIEW
	Set Time & Settings	CHANGE
Configuration	Display Configurations (Online)	VIEW
	Display Configurations (Offline)	None
	Load Configuration to IED	CHANGE
	Save Local Configuration	None
	Delete Local Configuration	None

8 Configuring the IED

Where the Setup Utilities of the previous chapter specify the IED's global characteristics, it is the IED's Configuration File that defines its individual channels and recording triggers.

The configuration file identifies and adjusts the device's input channels, record triggers. It also specifies how the device handles record storage and excessive trigger conditions. Configuration files are created and managed by TESLA Control Panel and loaded into the device's non-volatile memory through the communications link.

8.1 Managing Configuration Files

TESLA Control Panel's *Configuration Manager* creates and manages configuration files and handles transfer to and from the device. To open the Configuration Manager screen, double-click the *Configuration* line in the left pane of the Main Menu screen.

The configurations shown in the Configuration Manager screen are specific to the selected Current IED. To work with configurations from another device, you must first select that unit as the Current IED (from the Main Menu).

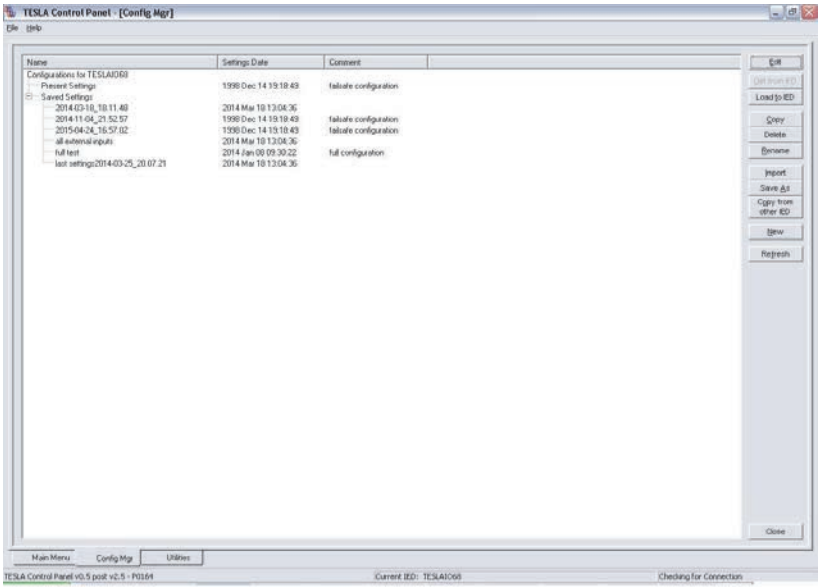


Figure 8.1: Configuration Manager

If a communication link to the Current IED is available, you can work directly with the device's configuration by either double-click on the *Present Settings* item in the list or by selecting *Present Settings* and using the *Edit* button. This will read the configuration from device and displays it in the Configuration Editor.

Editing an IED's Present Configuration

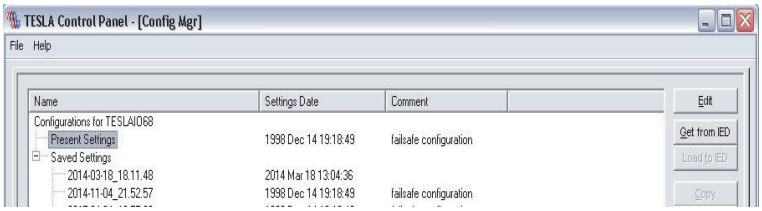


Figure 8.2: Present Configuration

When you close the Configuration Editor, you are given the option of loading the configuration back into the device. This gives you a quick way to make changes on the fly.

You can also transfer the device's present configuration to a saved file in Control Panel using the *Get from IED* button. When transferred, the configuration appears in the *Saved Settings* list.

Saved Configuration Files

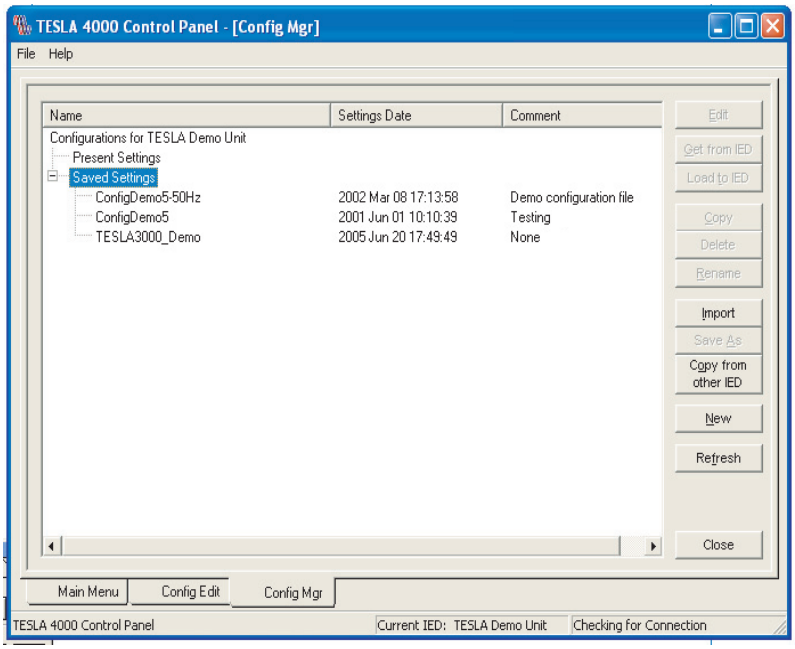


Figure 8.3: Saved Configurations

Saved configuration files are shown under the Saved Settings heading in the list. Control Panel can store many saved configuration files, limited only by hard disk and Windows operating system constraints.

Saved configuration files can be created, displayed and modified, copied, renamed, deleted or loaded into the unit. Click the desired configuration from the Saved Settings list, then select the appropriate action button on the right of the screen. Double-clicking on a configuration is equivalent to clicking the *Edit* button.

It is recommended that you maintain a copy of each device's current configuration as a Saved Setting for a backup. It can be loaded into a replacement IED if the unit ever needs to be serviced.

Note: A configuration file must be compatible with the firmware on the IED in order to be loaded. Compatibility is defined by the *Settings Version,* a number which identifies the version of configuration file a given version of firmware requires.

Control Panel will either prevent incompatible configuration files from being loaded or will offer to make the configuration compatible before it loads it.

Loading a Saved Configuration

To load a configuration file from the Saved Settings list into the Current IED, you must be communicating with the device. Initiate the load by selecting the desired configuration file and clicking the *Load to IED* button. The device will immediately load and run the new configuration. Complex configurations can take a few minutes to transfer and load, depending in part on communications rate. The device will acknowledge the new settings back to Control Panel.

Creating a New Configuration

Use the *New* button to create a new configuration file. New configuration files are compatible with the latest Setting Version by default.

The fixed information in the Device Configuration screen is derived from the IED Definition ("Adding/Editing a Device Workspace Definition" on page 5-3).

Using Another Device as a Starting Point

You can use the *Copy from Other IED* button to create a configuration for the current device based on an existing one from another IED. The configuration can be chosen from a list of the saved settings of the other IEDs defined in Control Panel.

8.2 SCADA and DNP Configuration

For SCADA communication and DNP configuration information, see “Accessing SCADA Services” on page 4-14.

For DNP protocol implementation details please refer to “DNP3 Device Profile” on page Appendix E-1.

8.3 IED Configuration Editor

The Configuration Editor provides the means to create, display and modify configurations for the device. To start the editor from the Configuration Manager screen, either double-click on a configuration file or select it and click on the *Edit* button.

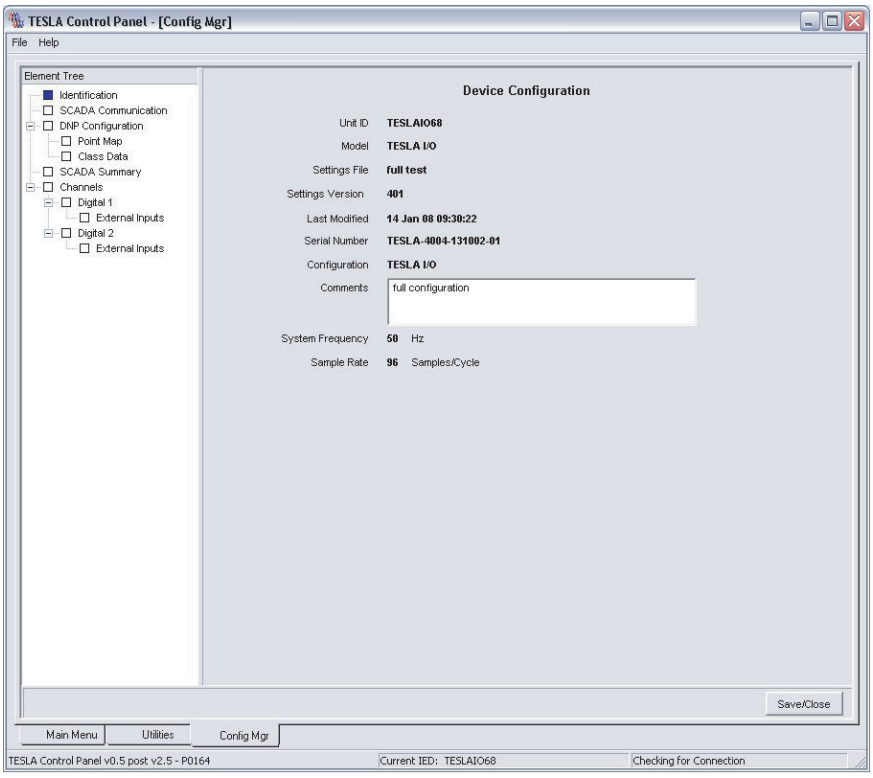


Figure 8.4: TESLA Configuration Editor

Navigation Tree

The left-side pane of the Configuration Editor window provides a navigation tree to access the various sections of the configuration. Selecting an item in the tree shifts the large right pane view to the appropriate topic. Double-clicking on a tree branch in the left pane that has a small “+” to its left or selecting on the “+” itself expands or collapses the tree.

Right-Click Menu

A right-click in the editor provides you with options appropriate to your present context. For example, you can create a new element by selecting the appropriate channel group, right-clicking and selecting *Add Element*.

Closing

The Close button is available to you when you are finished viewing or making changes to the Settings. If you made changes, the text on the Close button changes to Save/Close as a reminder that Control Panel gives you an opportunity to save your changes to a file (or send them to the IED) before closing the Configuration Editor. To close without saving changes, use the *Save/Close* button and then select *Exit Without Saving* and *Discard* on the subsequent screens.

8.4 Identification

Device Configuration

The Device Configuration screen is displayed when you select the Identification item in the Navigation Tree ("IED Configuration Editor" on page 8-4). It provides information about the selected IED and the particular configuration file being edited. Most of the information is drawn from the IED Definition and identifies the target device ("Adding/Editing a Device Workspace Definition" on page 5-3).

The Device Configuration screen has three configuration variables that are detailed below.

Settings Version

Compatibility between a configuration file and firmware versions is defined by the *Settings Version.*

The Settings Version required by a device is shown on the Unit Identification screen of the Utilities menu. You must be connected to the device to view this information. Settings Version requirements are also listed in the compatibility table at the front of this User Manual and are identified in each version's Release Notes.

> TESLA Control Panel should be updated as needed whenever you update the firmware on your device. This will ensure it can generate configuration files with the latest Settings Version.

Sample Rate

The *Sample Rate* setting controls the rate at which the device reads its digital input channels. The setting determines the number of samples per second stored in high speed fault records and used to display calculated high speed channels. The sample rate of the ERL Digital I/O Expansion module is fixed at 96 samples/cycle.

Comments

In the Comments section you can enter a description of the configuration for reference purposes. This description is also displayed in the configuration management screen to identify saved configuration files.

8.5 Channels and Triggers

The Channels and Triggers branch of the Navigation tree is where you define the IED's input channels and triggers.

Channel Grouping and Naming

With the large number of input channels available, it is worthwhile to apply consistent channel organization and naming conventions in your configuration. This section describes how the record handles channel names.

An effective way to organize the many channels available is to group them by the element they are monitoring. With the Configuration Mgr, you can identify each monitored element and use its name to group the digital channels associated with it.

Channel Types and Naming

Channel names consist of three parts: the Element Name, the Channel Type and an optional Descripton field. These fields are combined to produce the full channel name in the format:

Element:Type:Description

e.g. Line #1.EI.BRKR1_a

This is the name that will appear beside a channel when it is displayed in a graph or a log. For example the recorder's Event Log might contain this entry for a change in state of a external input:

2005 Jan 12 20:44:33.672 Line #1.EI.BRKK1_a open.

Details on the channel name components are given in the following table.

Table 8.6: Channel Names		
Element Name (10 chars)	Free-form text describing the power system element associated with this channel (e.g. Line #1). Channels that are logically related can be grouped through the use of the same element name.	
Channel Type	Standardized channel type descriptors are automatically generated when you select the channel type.	
	Examples	
	EI	External inputs
Description (optional) (12 chars)	Often the combination of the Element Name and the Channel Type is sufficient to fully identify a channel (e.g. Line #1:Va). In other cases, the Description is required to clarify the channel name. (e.g. You might name an external input channel as “Line #1:EI:BRKR1_a).	

Element Tree Views

The Config Mgr displays channels in Element View. The Element Tree View organizes channels by the element names you create.

Element Tree

The Element Tree View organizes channels by the element names you create.

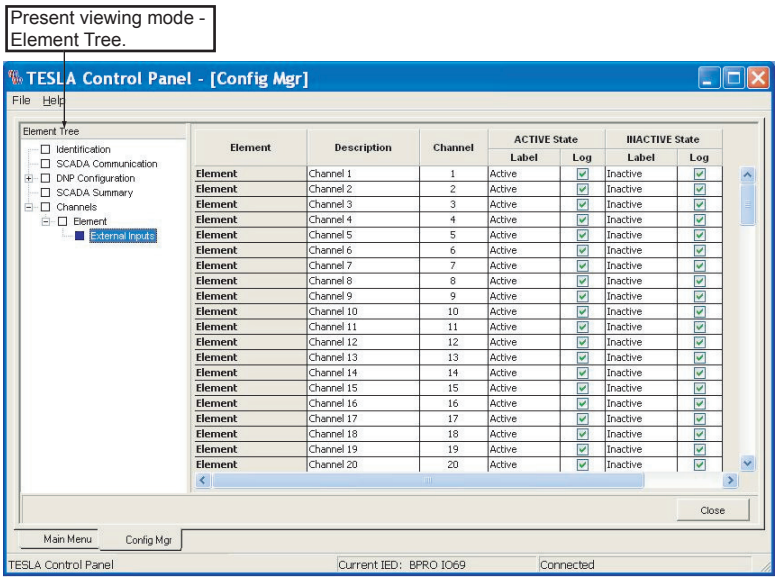


Figure 8.5: Element Tree View

Element Overview

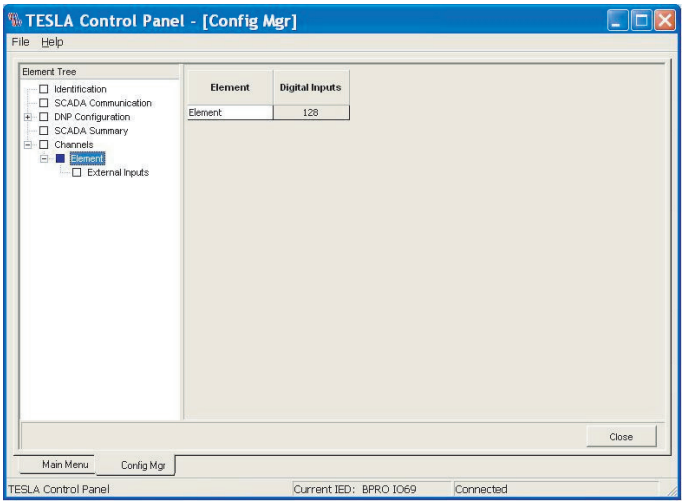


Figure 8.6: Element Overview Screen

Adding an Element

To create a new element you must be in the Element Tree view (“Element Tree Views” on page 8-7):

1. Right-click and select *Add Element* from the menu. *Add Element* creates the new element at the end of the present Element list.
2. Type the element name and *Enter*. The typed text replaces the *New Element* text.

Deleting an Element

To remove an element from the tree, select it, right-click and select *Delete Element* from the shortcut menu.

Adding a Channel

Channels can be created in either the Element Tree view or the Channel Tree View (“Element Tree Views” on page 8-7).

To create a new channel in the Element Tree view

1. Select the desired element in the tree.
2. Right-click and select the channel type. The new channel(s) will be inserted automatically in the list.

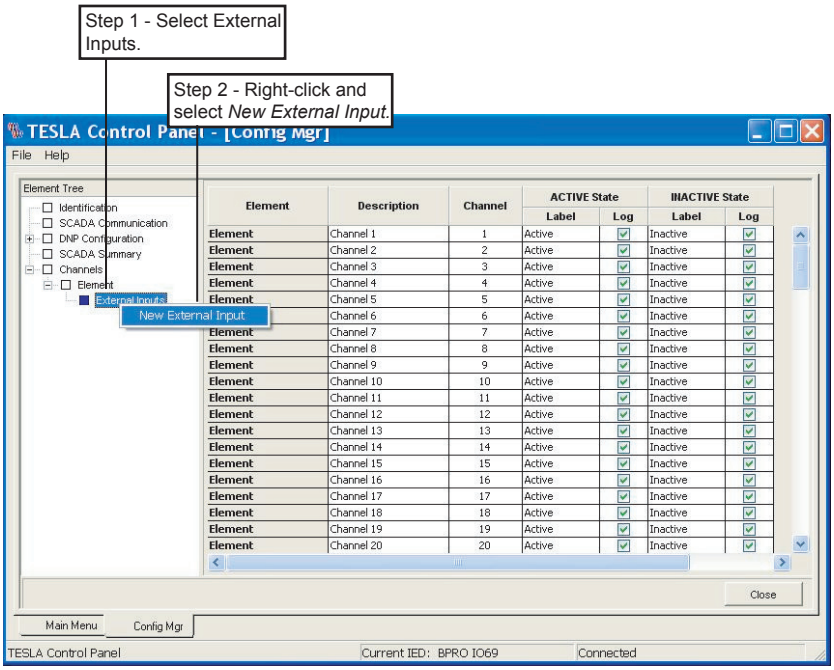


Figure 8.7: Adding External Input Channels from the Element Tree

Deleting a Channel

To remove a channel from the tree, select it, right-click and select the appropriate *Delete* entry from the shortcut menu.

8.6 External Input Channels

Description

Event Recording channels for the IED's external (digital) input signals.

Input

The IED's physical external input channels.

Calculation

The binary state of each external input is read at a sample rate of 96 samples/cycle. A filter is applied to the samples to prevent triggering on spurious state changes, requiring that a state change be present continuously for a minimum of approximately 700 microseconds to be considered valid for triggering purposes.

Triggers

- Active state
- Inactive state

Recording

Changes in active/inactive state of its external inputs are published as GOOSE messages by the ERL I/O Expansion and can be recorded by any IED subscribing to these messages.

the ERL I/O Expansion can also record on its virtual input channels the change in active / inactive state contained in any subscribed GOOSE messages

Number of Channels

Up to 128 External Input Channels can be defined, one for each physical input.

Types

EI

Settings

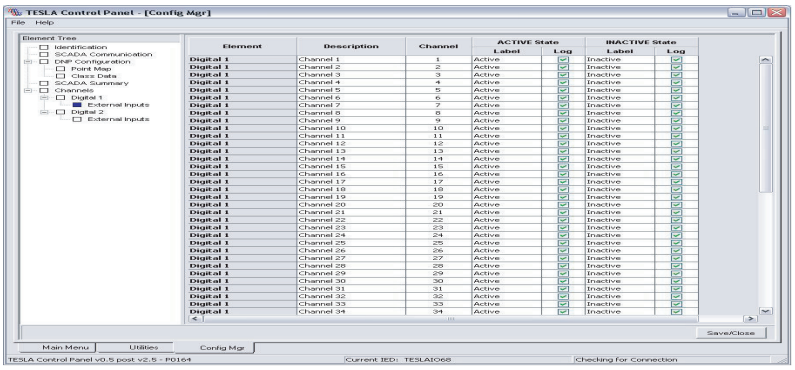


Figure 8.8: External Input Channel Configuration Screen

Table 8.7: External Input Channel Settings	
Element	Identifies the group to which this channel belongs. The Element forms the first part of the channel name.
Description	Optional field (12 characters). Provides an additional description of the channel that forms part of the channel name. Should always be used with External Input channels to uniquely name the channel. (“Channel Grouping and Naming” on page 8-6).
Channel	Identifies the physical External Input used by this channel.
Trigger Settings	
Label	Text to designate the active and inactive states. Maximum 8 characters.
Trigger Actions	
Log	Logs a message in the Event Log when triggered.

8.7 Printing

Printing a Configuration

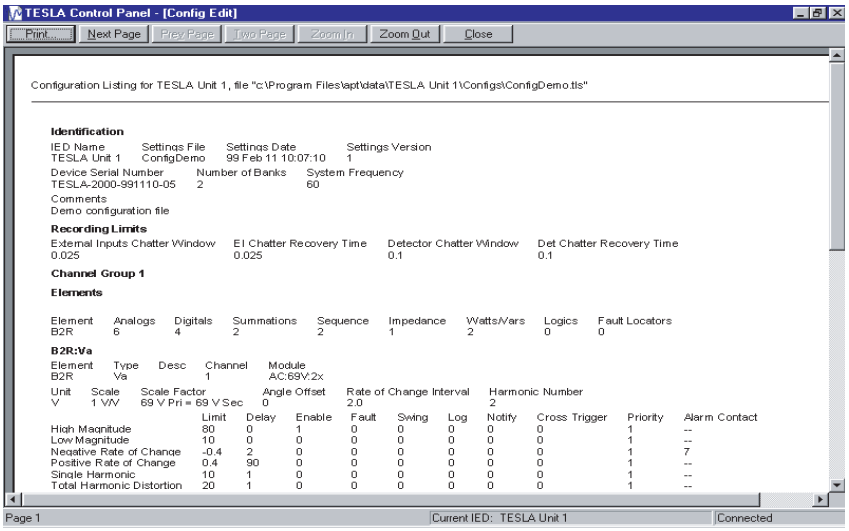


Figure 8.9: Print a Configuration

Generate a Configuration print at any time by selecting *Print Settings* from the *File* menu. The printed output follows the same general layout as the Element Tree.

You can preview the printed output by selecting *Print Preview* from the *File* menu.

Print Config function is also available under the *Config* menu.

Printing a SCADA Address List.

DNP

The DNP point list shows all of the functions defined in the IED, (see “DNP3 Device Profile” on page Appendix E-1) Selecting the *Print DNP* settings item from the *File* menu generates a listing that is configurable - listing the full function names in Element-Function-Description format along with the equivalent DNP points.

You can preview the printed output by selecting *Print DNP Preview* from the *File* menu.

Print DNP function is also available under the *Config* menu.

9 Record and Log Management

9.1 Recording

The I/O Expansion digital inputs are mapped to the logical device triggers for publishing. Any digital input status changes will be published as IEC 61850 GOOSE messages which can be used for triggering recording on TESLA 4000 and on any other IEDs capable of GOOSE subscription. Refer to the Appendix I ?IEC61850 Implementation? for more information on the I/O Expansion IEC 61850 implementation.

GOOSE messages published by other IEDs and mapped to the I/O Expansion?s subscription virtual channels shall be used to trigger a recording on the I/O Expansion. The recording will use the actual time stamp contained in the GOOSE messages. Use the ERL IEC 61850 Configurator to configure the I/O Expansion IED for recording digital input channels. This same method can be used for recording its own published GOOSE physical digital input status changes locally on the IED.

Records created on the I/O Expansion can be retrieved from the IED using the TESLA Control Panel software and viewed with the Record Graph graphical display and analysis tool. The allowed maximal number of records on the IO Expansion is 150. Once the maximal number of records is reached, I/O Expansion switches to record recycling mode.

9.2 Records

The Record management services are available from the *Records* tab, accessible from the *Main Menu*.

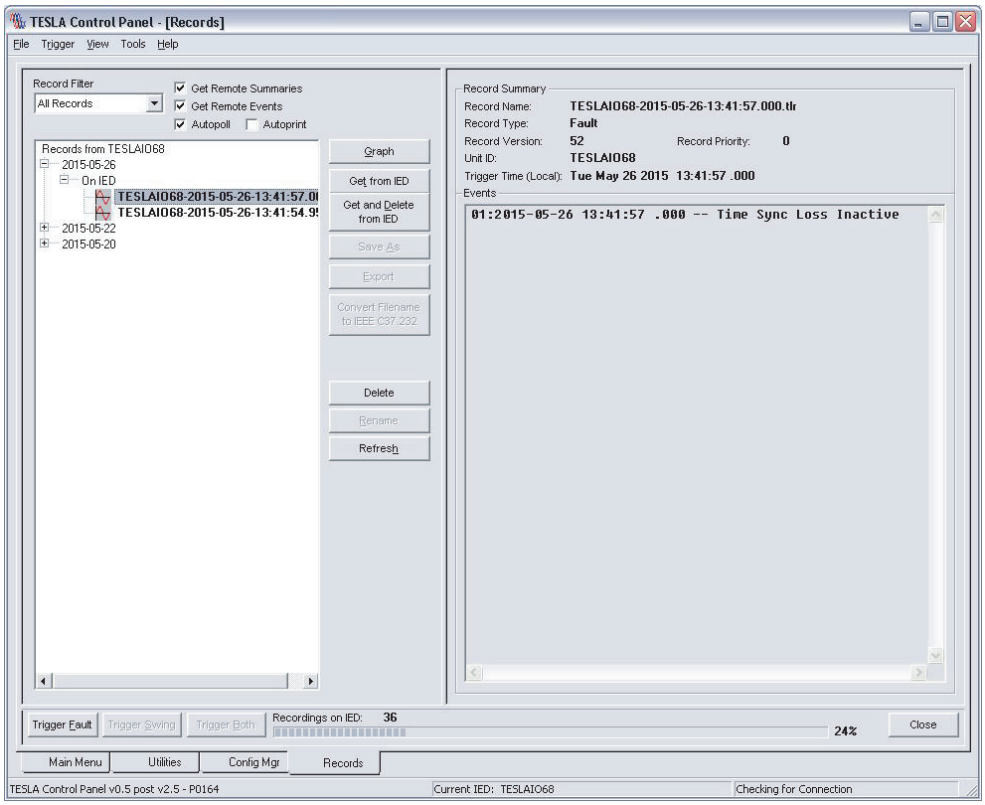


Figure 9.1: Record Listing

Record Lists

The left side of the *Records* tab shows lists of records for the current IED organized by date. Expanding a date entry shows *On IED* and *Local* headings. Records presently on the device are shown under the *On IED* heading. Records that have been previously transferred to TESLA Control Panel are shown under the *Local* heading. Records on the IED that have not been transferred to Control Panel are shown in bold-face. If working offline, only local records are shown.

Record Filter

The list of records displayed is controlled by the *Record Filter* control. The filter applies to both *On IED* and *Local* record lists. The time taken to access the directory can be controlled by selecting an appropriate number of records in the *Record Filter*.

Note that if additional recordings are created through the *Trigger Fault*, these new records do not displace the earliest fetch/displayed file records in the tree.

Record timestamps received from the device are in UTC and are converted to local time using the *Time Zone and Daylight Saving* settings of the computer running TESLA Control Panel

Record Summary

The right side of the *Records* tab shows summary information on the selected record. The summary includes the list of events which occurred during the time-span of the record from the device's event log.

Get Remote Summaries/Get Remote Events

When both *Get Remote Summaries* and *Get Remote Events* options are checked, Control Panel accesses and displays the corresponding recording information in the *Record Summary* and *Events* sections of the right-hand pane. You may eliminate the delay involved in accessing this information by disabling the corresponding check-boxes.

Autopoll/ Autoprint

When *Autopoll* is checked, Control Panel will periodically (default 60 seconds) poll the connected device for new record files and automatically transfer them to the local computer. Newest records will be transferred first, and only one new record will be transferred at each poll. The state of the *Autopoll* enable is persistent to the local computer and retained between TESLA Control Panel sessions and menu navigation. During periods of user inactivity, a count of *Autopoll* records transferred is indicated within the record tab when this feature is active.

Checking *Autoprint* will cause each transferred (via *Autopoll*) record file to be automatically printed on the default Windows printer using RecordGraph's default template. The state of the *Autoprint* enable is persistent to the local computer and retained between TESLA Control Panel sessions and menu navigation and only available when the *Autopoll* feature is enabled.

Graph

Records can be viewed with RecordGraph, ERLPhase's interactive graphing software. To launch RecordGraph, select one or more local records and select the *Graph* button.

Get from IED

Selecting a record file under *On IED* and then selecting the *Get from IED* button causes a record file on the IED to be transferred from the device to your local computer. More than one file can be transferred at the time using Windows file selection function (*Control*/*Shift* + *left*-click). This action will not delete the record on the IED.

Get from IED and Delete

The *Get From IED* and *Delete* button erases the records on the device after they have been transferred to Control Panel and verified.

Save As

Selecting a local record and selecting the *Save As* button copies a record to a specified file. The .tlr file suffix should be retained.

Export

Selecting a local record and selecting the *Export* button launches the Export Utility. Records can be exported in common formats such as COMTRADE for use in other software or playback, for details see "Record Export Utility" on page 11-1

.

Delete

The *Delete* button can be used to delete records on the IED or locally. More than one file can be deleted at a time using Windows file selection functions (*Ctrl/Shift + left-click*).

Rename

Select *Rename* to allow a local record file to be renamed. Records on the IED cannot be renamed.

Refresh

Selecting *Refresh* updates the *Recordings* screen. It checks the local directory and the remote IED (if connected) for new and stored files, updates Control Panel's records database and refreshes the screen.

Trigger Fault

The IED can be manually triggered to generate different types of records. *Trigger Fault* creates a high speed transient recording.

Recordings on IED

Shows the number of records stored on the device and percentage of recording space used.

File>Select Remote

This function is available through the *On IED* menu. If you are online with your IED, this function selects all of the recording files displayed in the record list that have not yet been transferred to your local Recordings directory. You may then perform whatever command is appropriate for the selection set, such as a *Get from IED* or a *Get and Delete from IED* Command.

9.3 Event Log

The event log services are available from the *Events* tab, accessible from the *Main Menu*.

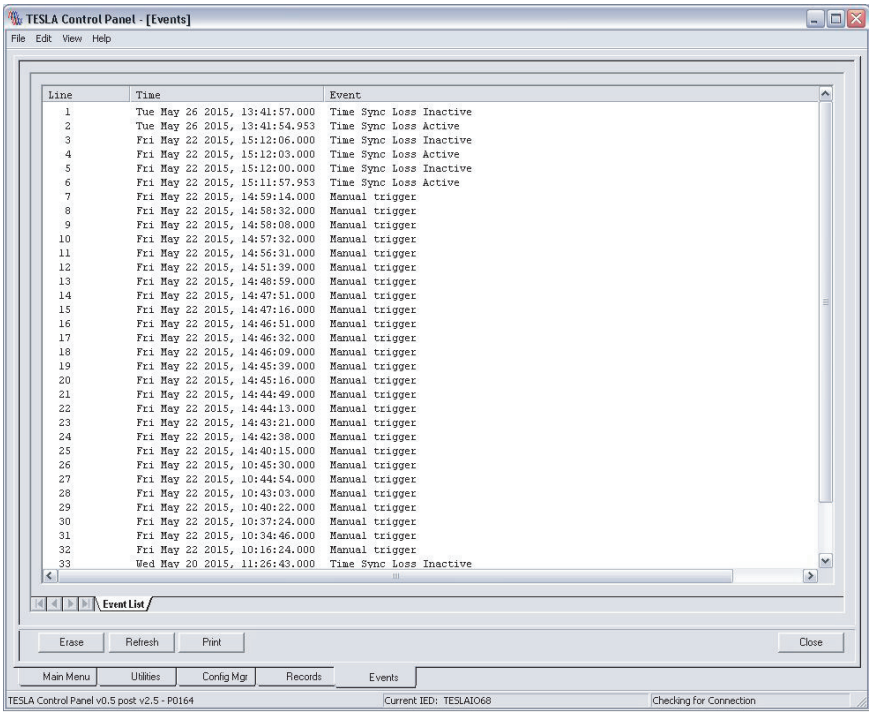

TESLA Control Panel - [Events]
File Edit View Help
Line Time Event
1 Tue May 26 2015, 13:41:57.000 Time Sync Loss Inactive
2 Tue May 26 2015, 13:41:54.953 Time Sync Loss Active
3 Fri May 22 2015, 15:12:06.000 Time Sync Loss Inactive
4 Fri May 22 2015, 15:12:03.000 Time Sync Loss Active
5 Fri May 22 2015, 15:12:00.000 Time Sync Loss Inactive
6 Fri May 22 2015, 15:11:57.953 Time Sync Loss Active
7 Fri May 22 2015, 14:59:14.000 Manual trigger
8 Fri May 22 2015, 14:58:32.000 Manual trigger
9 Fri May 22 2015, 14:58:08.000 Manual trigger
10 Fri May 22 2015, 14:57:32.000 Manual trigger
11 Fri May 22 2015, 14:56:31.000 Manual trigger
12 Fri May 22 2015, 14:51:39.000 Manual trigger
13 Fri May 22 2015, 14:48:59.000 Manual trigger
14 Fri May 22 2015, 14:47:51.000 Manual trigger
15 Fri May 22 2015, 14:47:16.000 Manual trigger
16 Fri May 22 2015, 14:46:51.000 Manual trigger
17 Fri May 22 2015, 14:46:32.000 Manual trigger
18 Fri May 22 2015, 14:46:09.000 Manual trigger
19 Fri May 22 2015, 14:45:39.000 Manual trigger
20 Fri May 22 2015, 14:45:16.000 Manual trigger
21 Fri May 22 2015, 14:44:49.000 Manual trigger
22 Fri May 22 2015, 14:44:13.000 Manual trigger
23 Fri May 22 2015, 14:43:21.000 Manual trigger
24 Fri May 22 2015, 14:42:38.000 Manual trigger
25 Fri May 22 2015, 14:40:15.000 Manual trigger
26 Fri May 22 2015, 10:45:30.000 Manual trigger
27 Fri May 22 2015, 10:44:54.000 Manual trigger
28 Fri May 22 2015, 10:43:03.000 Manual trigger
29 Fri May 22 2015, 10:40:22.000 Manual trigger
30 Fri May 22 2015, 10:37:24.000 Manual trigger
31 Fri May 22 2015, 10:34:46.000 Manual trigger
32 Fri May 22 2015, 10:16:24.000 Manual trigger
33 Wed May 20 2015, 11:26:43.000 Time Sync Loss Inactive
Event List
Erase
Refresh
Print
Close
Main Menu
Utilities
Config Mgr
Records
Events
TESLA Control Panel v0.5 post v2.5 - P0164
Current IED: TESLAIO68
Checking for Connection

Figure 9.2: Event Log Display

The IED maintains a log of time-stamped events. Event messages can be produced by any of the device's detectors if configured to do so.

Event messages can also be viewed in the Record Summary display.

Circular Storage

The Event Log stores up to 500 events with automatic overwrite of the oldest event.

Event Messages

The text of an event message is derived from the configuration of the detector that generates it.

The general format for event message is:

Line# Date/Time ElementDescription

where:

- *Description* is user-assigned text available to further identify the detector

Example of event messages:

- 20 Thu May 14 2015, 09:05:17.607 test 1:DI8:Digital 8 Active
- 21 Thu May 14 2015, 08:54:06.000 Manual trigger

Printing Event Log

You may print or copy to clipboard all the events that are in the Event Log. Choose from the menu bar to print event logs while connected to the IED.

Controls

The event display is a static snapshot of the contents of the event log. You can use the buttons at the bottom to access the Erase, Refresh, Print functions. In addition, print commands are available under the File menu, a copy command is available under the Edit menu, and a refresh command is available under the View menu.

Table 9.8: Event Log

Copy	Copies the event list to clipboard for pasting to other programs,
Refresh	Updates Event List by getting a new list from remote IED and updates the Event List screen.
Erase	Removes all events from remote IED.
Print	Prints all the events (up to 500 events) to a local printer.

10 Graphing Records

10.1 Getting Started

RecordGraph is a tool used to display and analyze records from ERLPhase relays and recorders. Use it to graphically view the data recorded during fault. RecordGraph is integrated with TESLA Control Panel.

Launch RecordGraph from TESLA Control Panel

Method 1: Records

1. Open TESLA Control Panel by double-clicking on the *TESLA* icon on your desktop. If the application is not installed, install the application and then proceed.
2. Double-click on the *Records* item in the tree list or select *Records* and use the *Enter* key.
3. Using the *Records* tab, select a local record from the tree list.
4. Click the *Graph* button.

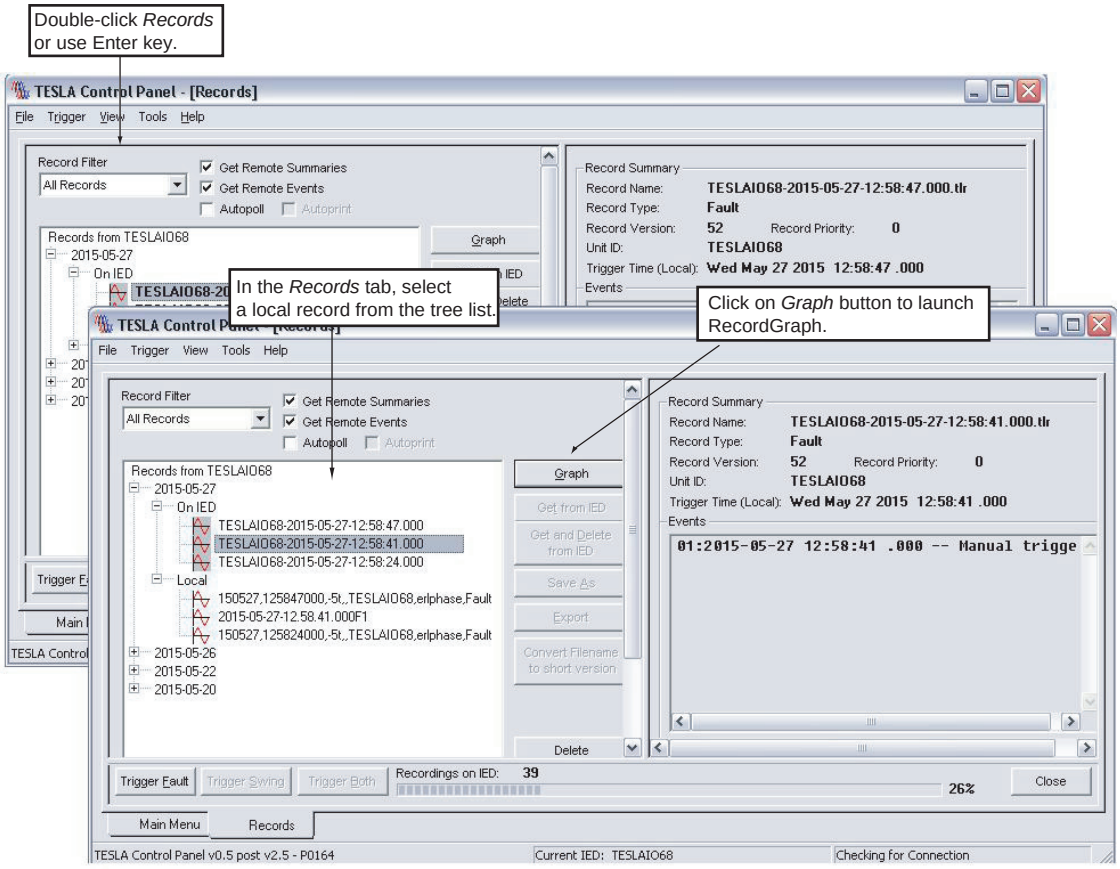


Figure 10.1: Launching RecordGraph from TESLA Control Panel

When the Graph button is clicked from the TESLA Control Panel, RecordGraph is launched with the selected record.

Method 2: Auto Print

If the Auto Print option is checked (enabled) in the Records list view, then RecordGraph will be automatically launched and prints the channels directly on to the Default printer. The layout and channel information is predefined in the <Default> or User-defined template.

Launch RecordGraph from Windows Explorer

1. Open Windows Explorer.
2. Select a record. (It should have valid extensions, *.lpr, *.lpl, *.tpr, *.tpt, *.tlr, *.bpr, *.bpl, *.fpr, *.mbr, *.mbe.)
3. Right-click the selected record.
4. Choose, the *RecordBaseView>Launch Graph* option.

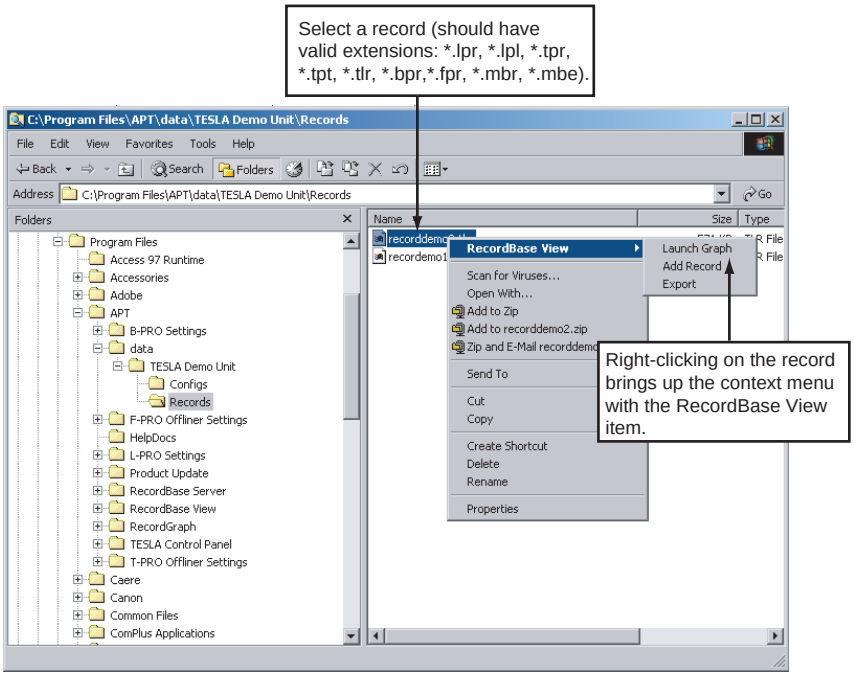


Figure 10.2: Launching RecordGraph from Windows Explorer

RecordGraph Components

- Main menu items
- Tool bar buttons
- A drop-down box lists the templates associated with the current record's IED
- A left-hand side pane (LHS) or tree view lists the names of records to be displayed or analysed
- A right-hand side pane (RHS) displays the graphs in various views. Initially a single blank screen appears.
- A right-click context menu on both the LHS and RHS panes.
- RecordGraph version is displayed in the *Help>About RecordGraph*.

Menus

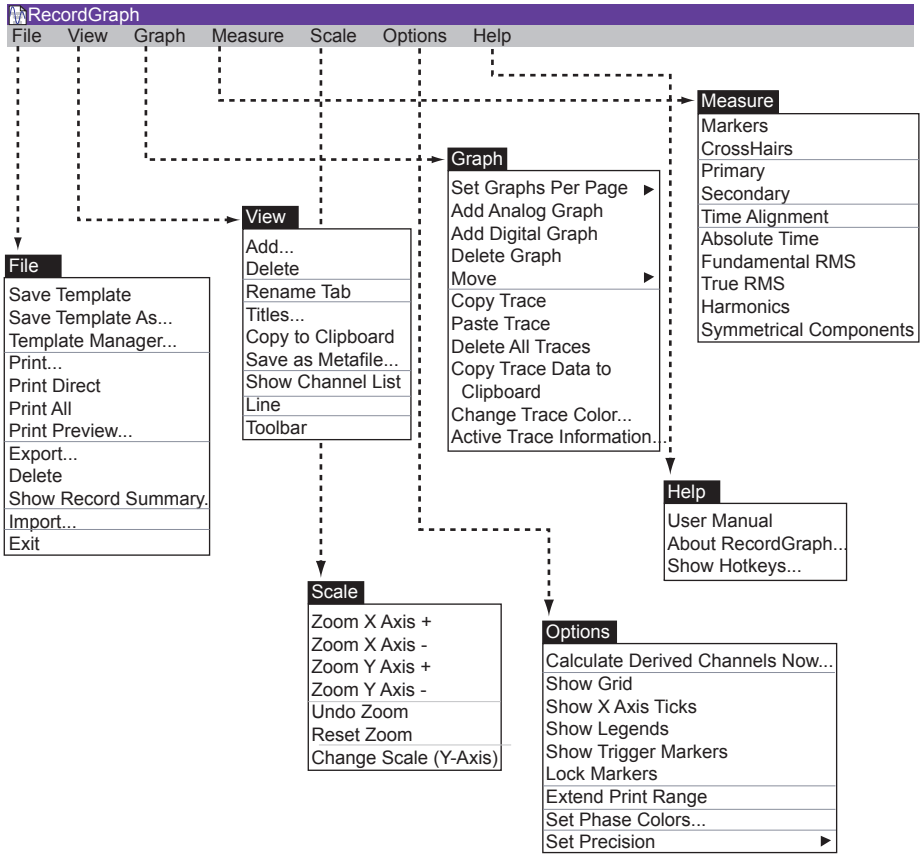


Figure 10.3: Menus

10.2 RecordGraph Menu Items

Help Menus

Help>User Manual

Select to display an electronic version of the user manual.

Help>About RecordGraph

Display program information, version number and copyright.

Help>Show Hot Keys

Lists the available hot keys or short cuts.

Tool Bar Buttons

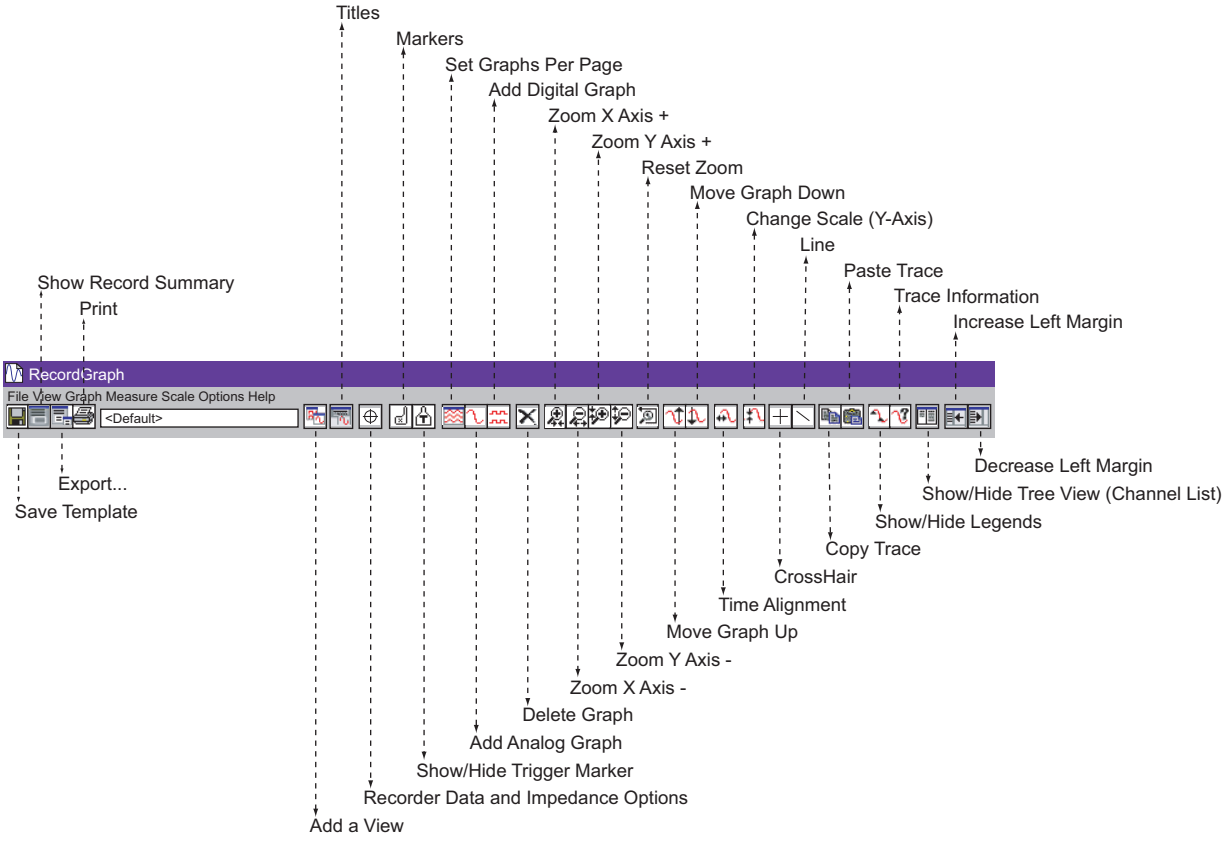


Figure 10.4: Tool Bar Buttons

In the Tree View, you can expand a loaded record to identify the recorded and calculated channels (if configured). A right-click menu is available to manipulate the tree items. Most of the tool bar buttons work in a similar way to that of the menu items explained in the previous sections.

Table 10.9: Tool Bar Buttons	
Save Template	Save template file on the disk.
Show Record Summary	Displays record summary (events, trigger time, etc.)
Export	Brings up export module.
Print	Prints record.
Add a View	Adds a graph view that displays the fault information.
Titles	Places a title above graph for all views
Impedance	Creates an R-X plot before, during and after fault.
Markers	Displays vertical lines "x" and "o" to find the coordinate values on the graph.
Show/Hide Trigger Marker	Displays/hides zero trigger marker.
Set Graphs Per Page	Sets number of graphs per page.
Add Analog Graph	Add an analog graph.
Add Digital Graph	Add a digital graph.
Delete	Delete a graph.
Zoom X Axis +	Enlarges the trace range on X axis.
Zoom X Axis -	Reduces the trace range on X axis.
Zoom Y Axis +	Enlarges the trace range on Y axis.
Zoom Y Axis -	Reduces the trace range on Y axis.
Reset Zoom	Resets zoom control.
Move Graph Up	Vertically moves graph upwards.
Move Graph Down	Vertically moves graph downwards.
Time Alignment	Offset X axis time value.
Change Scale (Y Axis)	Scale Y axis minimum and maximum range.
CrossHair	Displays X and Y coordinate values.
Line	Available only for impedance view, draws a reference line.
Copy Trace	Copies a trace to another location.
Paste Trace	Pastes a trace.
Show/Hide Legends	Displays/hides legends the traces.
Trace Information	Displays/hides channel information: Date, Station Name, RecordName, Channel Name.
Show/Hide Tree View Channel List	Expands and minimizes RHS of the screen.
Decrease Left Margin	Decreases left margin.
Decrease Right Margin	Decreases right margin.

10.3 Digital Channel Status Indicator

Highlight digital channel which change state (with different icons), and list only configured channels in the tree view. A mimic screen shot of the icons is shown below. The <default> template automatically displays the digital channels which changes the state.

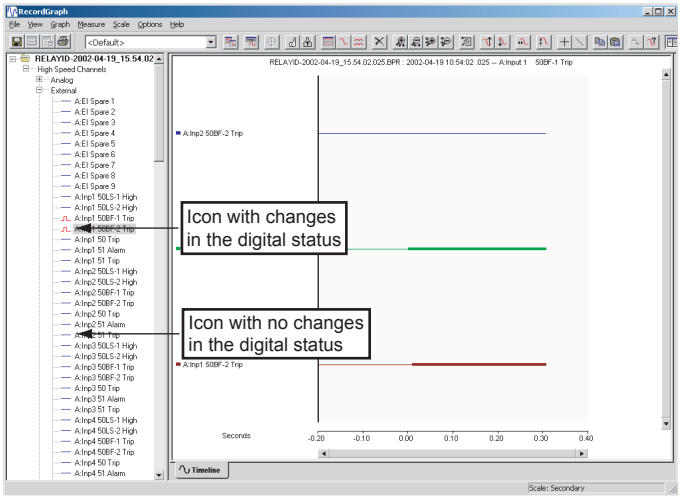


Figure 10.5: Digital Channel Status Indicator

10.4 Time Sync Input Status

Time Sync input status (synchronized, unsynchronized or not available) is displayed in the tool tip window when you place the mouse on the channel name or use Active Trace Information. Additional information related to the time source (IRIG-B, SNTP, etc.) will also be available as a portion of the Time Sync status.

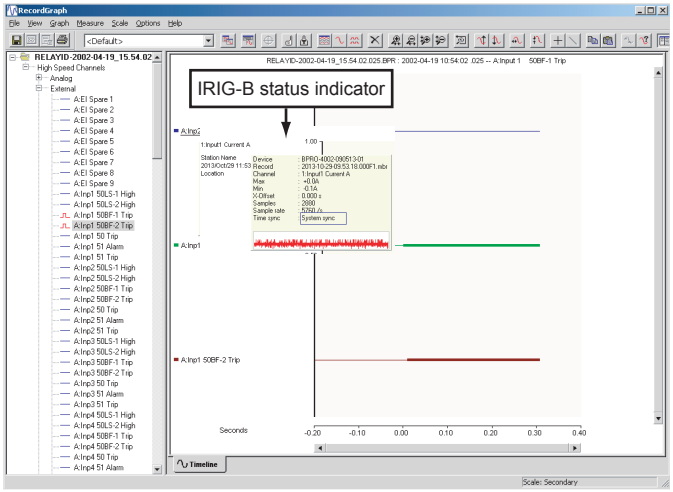


Figure 10.6: Select COMTRADE File

10.5 Derived External and Virtual Input Channels for TESLA Swing Recordings

TESLA recordings do not record External Input and Virtual Input channels for the swing records. A facility to view these channels in the RecordGraph is provided. RecordGraph automatically displays these channels (if configured) under the low speed channel group. Events with the same element are grouped together to form a channel. This facility is backward compatible.

10.6 COMTRADE Import

COMTRADE (Common Format for Transient Data Exchange) is an industry standard record format used to share data between tools and to replay faults through a test set. The import utility supports viewing of both ASCII and binary COMTRADE formats (1991, 1999 and 2000). When the COMTRADE file is imported into the RecordGraph, all its functionality can be seamlessly used to analyze the record.

1. RecordGraph application must be running to access this facility. If not, launch RecordGraph via TESLA Control Panel, RecordBase View or Windows Explorer.
2. Choose *File>Import*.
3. Browse to select desired file.
4. Double-click on the COMTRADE record to apply <Default> template or select it from the templates list box.

10.7 Print Options

The following options are available:

- Print... – pops-up a print option dialog box to select paper size, orientation and other options.
- PrintDirect – sends active view directly to the default printer.
- PrintAll – sends all the views directly to the default printer.
- Print Preview…– displays standard preview window.

11 Record Export Utility

The record export utility lets you convert records into different formats for use with other software tools.

COMTRADE

Common Format for Transient Data Exchange (COMTRADE) is an industry standard record format used to share data between tools and to replay faults through a test set. The export utility supports both ASCII and binary COMTRADE formats and creates output that complies with the latest (1999) or older version (1991) of the standard.

PTI

Power Technologies Incorporated (PTI) produces widely used power system modelling tools. Records can be exported in a PTI-compliant format for import into PTI tools. The export utility supports ASCII format and creates output that complies with PTI version 1 or version 2 formats.

Excel (CSV)

Records can be exported in basic comma separated values (also known as comma-delimited) ASCII format suitable for importing into standard tools such as Microsoft Excel.

Launch the Export Utility

To launch the export utility:

1. Double-click *Records* from the *Main Menu*.
2. Select a local record from the record list.
3. Select the *Export* button to launch the Export window.
4. Select the desired export output format and select *OK*.

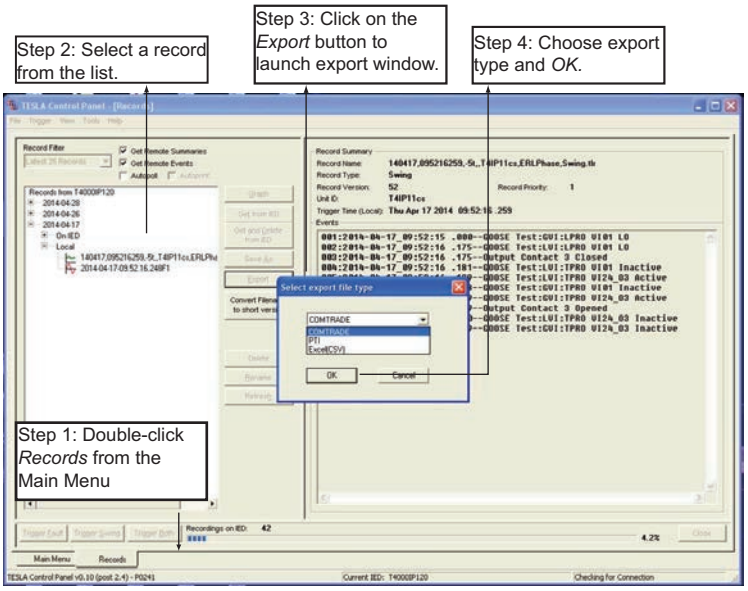

Step 2: Select a record from the list.
Step 3: Click on the *Export* button to launch export window.
Step 4: Choose export type and *OK*.
Step 1: Double-click *Records* from the Main Menu

Figure 11.1: Select Export File Type

11.1 COMTRADE Format

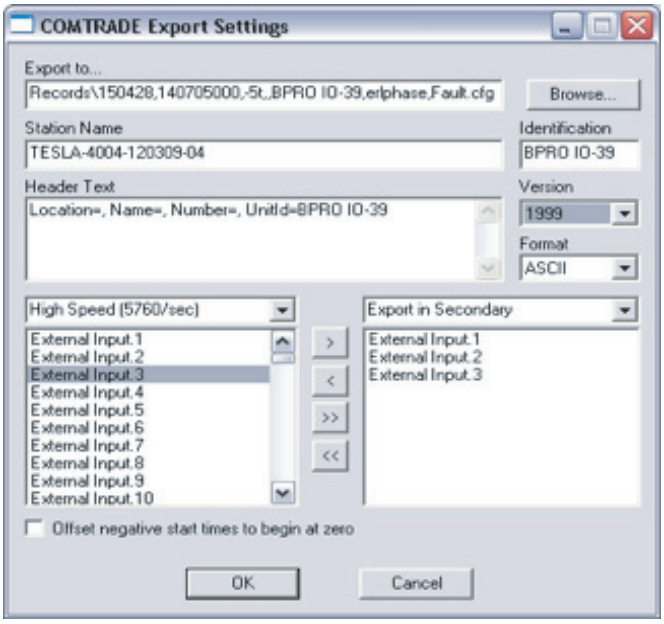


Figure 11.2: COMTRADE Settings

The COMTRADE format (IEEE C37.111) defines a common format for storing digital data records of transient events. It consists of up to four output files with the same base name and different file extensions: configuration files (.cfg), header files (.hdr), data files (.dat) and optional information files (.inf). The COMTRADE Export Utility produces the configuration, header and data files.

With reference to Figure 11.2: COMTRADE Settings,

Table 11.1: COMTRADE Export Settings

Name	Function
Export to...	The base filename and directory of the output files are set using the Export to. option. By default the base filename is the same as the record you are exporting. You can edit this or use the Browse button to set a new directory and/or base filename.
Station Name and Identification	The Station Name and Identification fields are set by default using information from this recorder. They are written as the first line in the.cfg output file.
Header Text	The Header Text field contains the text written into the COMTRADE header (.hdr) file. By default, the field contains the Location, Name, Number and the Unit ID of the unit that produced the record. This text can be modified, deleted or extended as desired.

Table 11.1: COMTRADE Export Settings	
Version	The Version field lets you select the revision of COMTRADE standard to produce. COMTRADE has been an evolving standard and a number of changes have been made over the years. 1991 and 1999 COMTRADE versions are supported.
Format	The Format field specifies that the data in the COMTRADE file (ASCII or BINARY format). ASCII data has the advantage of being usable by simple text editor and spreadsheet programs, but results in a significantly larger record relative to binary format. BINARY format is therefore recommended if the software package you will be using the data in supports binary format COMTRADE.
Selecting Channels (Exported Channels)	You must select the channels from the record that you want to include in the output file. For convenience, the digital data recorded is classified into: • High Speed: Analog and external digital input channels sampled at the high speed transient data rate. • High Speed (480/sec): Analog and internal logic channels produced 8 times per cycle. • Low Speed (60/sec): Analog input channels sampled at the low speed swing data rate. Select the desired channel from the list with a left-click. Multiple channels can be selected using standard Windows selection actions (click + Ctrl or Shift keys).
>	Place selected channels in the Exported Channels list box.
>>	Place all channels into the Exported Channels list box.
<	Delete a channel from the Exported Channel list box.
<<	Delete all channels from the Exported Channel list box.
Offset negative start times to begin at zero	When checked, this option shifts the negative time to start from zero.

11.2 PTI Format

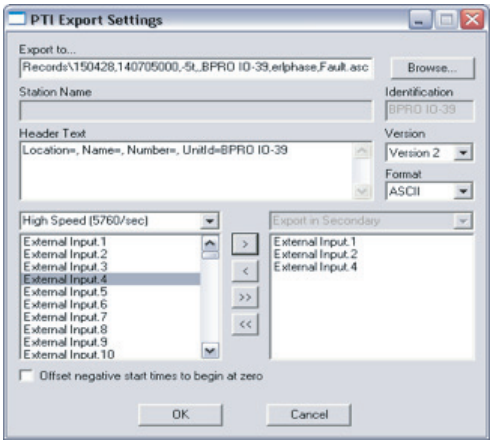


Figure 11.3: PTI Settings

The PTI file format is used to import records into the Power Technologies Incorporated system modelling software.

Output File PTI export produces a single output file with an .asc extension.

Table 11.2: PTI Settings

Name	Title
Export to...	The base filename and directory of the output files are set using the Export to. option. By default the base filename is the same as the record you are exporting. You can edit this or use the Browse button to set a new directory and/or base filename.
Station Name and Identification	The Station Name field is set by default using the unit's Station Name setting. It is written as the third line in the output file. If desired, you can edit this text. The Identification field is not written to the PTI output file.
Header Text	The Header Text field contains the text that is written as a single line in the fourth line in the output file. By default, the field contains the Location, Name, Number and Unit ID of the recorder that produced the record. This text can be modified, deleted or extended as desired.
Version	The Version field lets you select between PTI version 1 and version 2. Please refer to PTI documentation for details on the differences of these versions. Format Only ASCII format output files are available.
Format	ASCII is the only format option for PTI.

Table 11.2: PTI Settings	
Channel Selection	Use Channel Selection to select channels to export. You must select the channels from the record that you want to include in the output file. For convenience, the digital data recorded is classified into: • High Speed: Analog and external digital input channels sampled at the high speed transient data rate. • High Speed (480/sec): Analog and internal logic channels produced 8 times per cycle. • Low Speed (60/sec): Analog input channels sampled at the low speed swing data rate. Select the desired channel from the list with a left-click. Multiple channels can be selected using standard Windows selection actions (click + Ctrl or Shift keys).
>	Place selected channels in the Exported Channels list box.
>>	Place all channels into the Exported Channels list box.
<	Delete a channel from the Exported Channel list box.
<<	Delete all channels from the Exported Channel list box.
Offset negative start times to begin at zero	When checked, this option shifts the negative time to start from zero.

11.3 Excel (CSV) Format

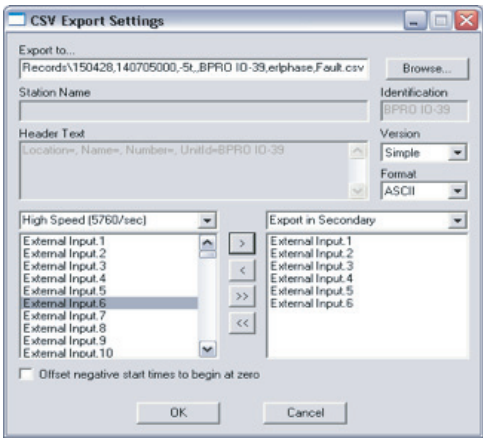


Figure 11.4: Excel (CSV) Settings

The Excel CSV (Comma Separated Value) format is used to import records into a Microsoft Excel spreadsheet. This format is also known as comma delimited ASCII and can generally be used by most programs that import data arrays.

Excel CSV export produces a single output file with a .csv extension, which is recognized by Excel. Excel is automatically launched when you double-click on file.

Table 11.3: CSV Export Settings

Name	Function
Export to...	The base filename and directory of the output files are set using the Export to... option. By default the base filename is the same as the record you are exporting. You can edit this or use the Browse button to set a new directory and/or base filename.
Station Name and Unit ID	The Station Name and Identification fields are not written to the Excel CSV format output file.
Header Text	There is no header text written to the Excel CSV format output file.
Version	There are no version options for the Excel CSV output.
Format	ASCII is the only format options for the Excel CSV output.

Table 11.3: CSV Export Settings	
Channel Selection	You must select the channels from the record that you want to include in the output file. For convenience, the digital data recorded is classified into: • High Speed: Analog and external digital input channels sampled at the high speed transient data rate. • High Speed (480/sec): Analog and internal logic channels produced 8 times per cycle. • Low Speed (60/sec): Analog input channels sampled at the low speed swing data rate. Select the desired channel from the list with a left-click. Multiple channels can be selected using standard Windows selection actions (click + Ctrl or Shift keys).
>	Place selected channels in the Exported Channels list box.
>>	Place all channels into the Exported Channels list box.
<	Delete a channel from the Exported Channel list box.
<<	Delete all channels from the Exported Channel list box.
Offset negative start times to begin at zero	When checked, this option shifts the negative time to start from zero.

11.4 IEEE C37.232 TSD File Naming

The TESLA Control Panel software utility (v2.5 or better) supports the use of the C37.232-2011 IEEE Standard for Common Format for Naming Time Sequence Data Files (COMNAME). Feature set-up is accessed by selecting Tools > Options in the Records Tab main menu, allowing the user to activate the C37.232 conversion capability at a workstation level. A company Name entry is required and use as a portion of the filename construction.

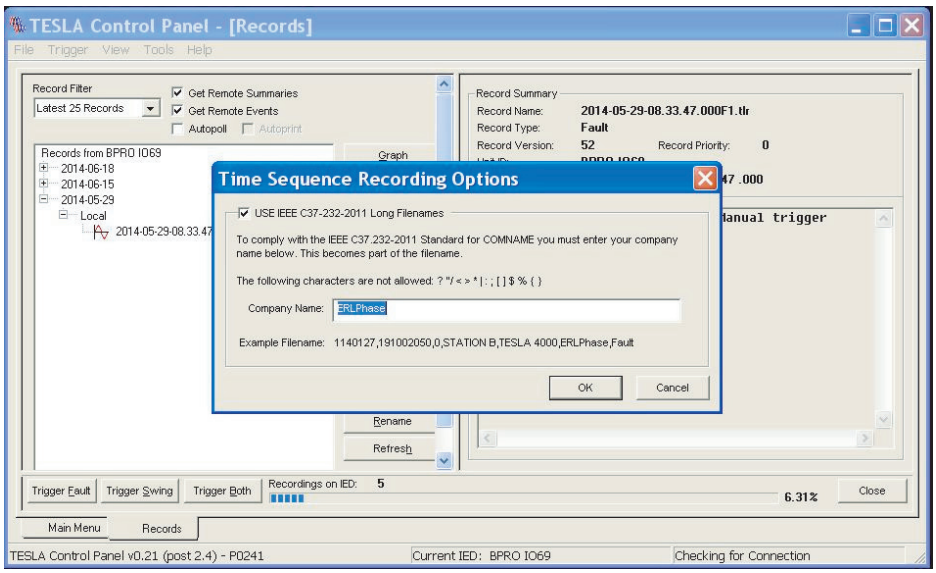


Figure 11.5: Time Sequence Data (TSD) Record Settings

Feature activation allows local TSD Record names to be toggled between ERLPhase proprietary and C37.232 file naming structures. This does not affect records currently stored on the IED.

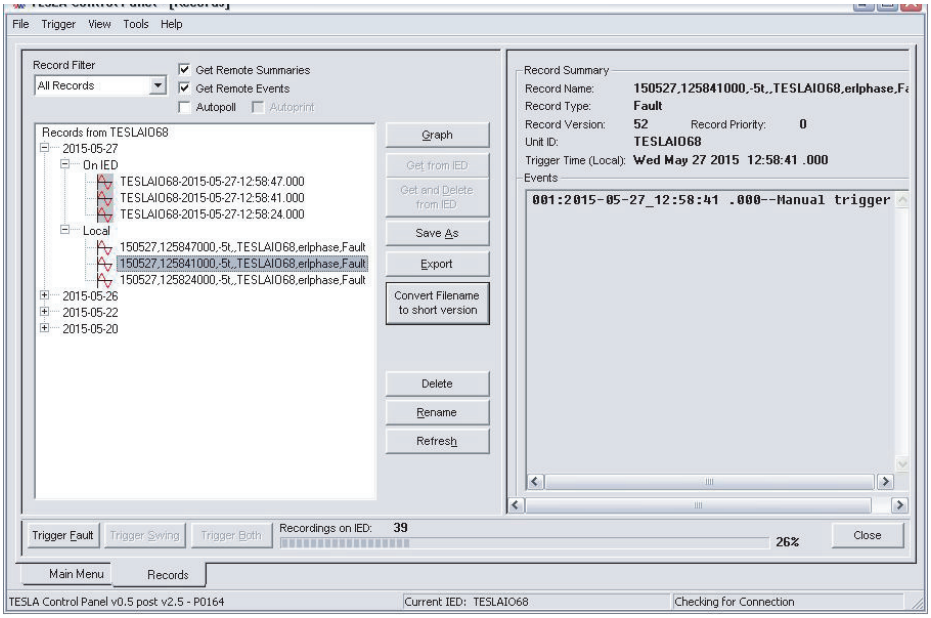


Figure 11.6: IEEE C37.232 Filename Conversion Feature

12 Maintenance Menu and Error Handling

12.1 Maintenance Menu

The ERL I/O Expansion unit has a set of utilities that provide diagnostic, recovery and TCP/IP services. These utilities are available through the Maintenance Menu accessed with a VT-100 terminal connection to the device's Ethernet LAN or USB port. For security purposes any utilities that can modify the unit are disabled when connecting remotely. To access these utilities you must connect to the device using Port 450 on the unit's front panel.

Any terminal program that fully supports VT-100 emulation and provides z-modem file transfer services can be used. HyperTerminal, which is included in Windows XP and is also available separately as HyperTerminal PE, is used here as an example.

1. Determine how you want to connect to the device.
   - USB connection.
   - If both the device and your computer are on the same LAN or WAN, you can access the Maintenance Menu through your network.
2. Configure your terminal program as described in the table below.
   - For a USB link the baud rate must be same as that of the device's port. Port 450 USB link the default baud rate is 115,200. The baud rate can be viewed and changed in the *Utilities>Communication* tab of TESLA Control Panel.
   - For a network link, only the Emulation and Font settings from the table are relevant.

Table 12.1: Terminal Program Setup	
Baud rate	For a USB or direct serial link, the baud rate must match that of the device's port. USB Port 450 default baud rate is 115,200 N81.
Data bits	8
Parity	None
Stop bits	1
Flow control	Hardware or Software. Hardware flow control is recommended. The unit automatically supports both on all its serial ports.
Function, arrow and control keys	Terminal keys
Emulation	VT100
Font	A font that supports line drawing (e.g. Terminal or MS Line Draw). If the menu appears outlined in odd characters, the font you have selected is not supporting line drawing characters.

3. Select the device on your PC you will communicate through. In HyperTerminal, this is done in the Connect Using field of its Properties control.
   - For a USB link select port 450
   - For a network link, select "TCP/IP (Winsock)" (available with HyperTerminal v1.2 or greater)
4. Initiate the connection. The unit will respond with a login prompt
   - In HyperTerminal, use the Call button or menu command to initiate the connection.
5. At the login prompt, log in as "maintenance"
   - Lower case
   - No password is required. If you are asked for one, there is a mistake in the login name. Press Enter to get another Login prompt and try again.

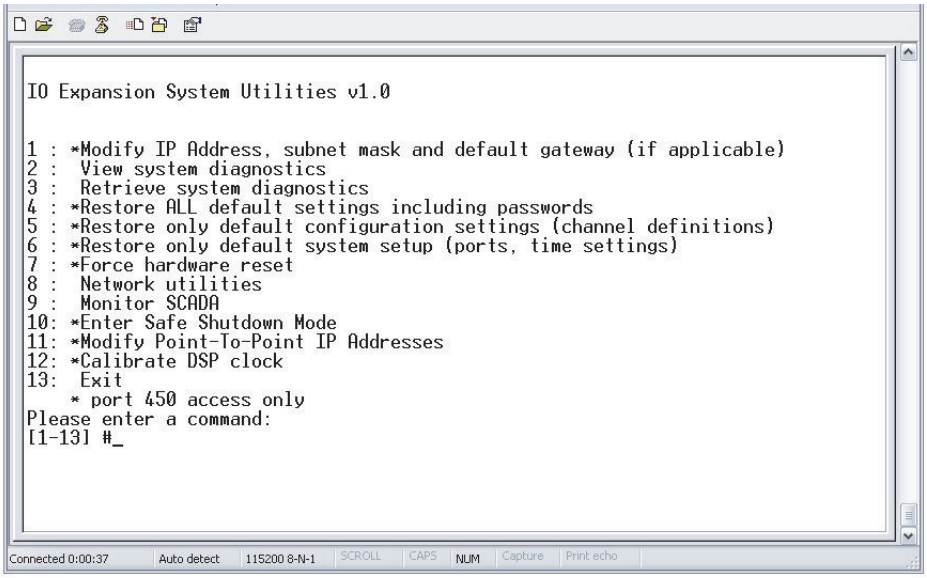

IO Expansion System Utilities v1.0
1 : *Modify IP Address, subnet mask and default gateway (if applicable)
2 : View system diagnostics
3 : Retrieve system diagnostics
4 : *Restore ALL default settings including passwords
5 : *Restore only default configuration settings (channel definitions)
6 : *Restore only default system setup (ports, time settings)
7 : *Force hardware reset
8 : Network utilities
9 : Monitor SCADA
10: *Enter Safe Shutdown Mode
11: *Modify Point-To-Point IP Addresses
12: *Calibrate DSP clock
13: Exit
* port 450 access only
Please enter a command:
[1-13] #_
Connected 0:00:37
Auto detect
115200 8-N-1
SCROLL
CAPS
NUM
Capture
Print echo

Figure 12.1: Maintenance Menu

Maintenance Menu Commands

Table 12.2: Menu Commands

1. Modify IP Addresses, subnet mask and default gateway	Modify the LAN IP addresses, default subnet mask and default gateway.
2 View system diagnostic	Displays the IO Expansion's internal status log.
3 Retrieve system diagnostics	Automatically packages up the internal status log plus setting and setup information and downloads it in compressed form to your computer. This file can then be sent to ERLPhase customer support to help diagnose a problem.
4 Restore ALL default settings	Restores ALL factory defaults including settings, calibration and setup parameters.
5 Restore only default configuration settings	Restores the default settings that define channels, sample rates and triggers.
6 Restore only default system setup	Restores the default values for the setup parameters including communication settings, record controls, time controls and passwords.
7 Force hardware reset	Manually initiates a hardware reset. Note that the communication link is immediately lost and cannot be re-established until the unit completes its start-up.
8 Network utilities	Enter network utilities sub-menu.
9 Monitor SCADA	Shows real time display of Modbus or DNP 3 data.
10 Enter safe shutdown mode	Suspends IO Expansion application and stops FLASH Drive operations. This should be executed prior to cycling power to the unit to prevent accidental FLASH Drive corruption.
11 Modify point-to-point IP addresses	Modify point-to-point addresses used for TCP/IP communication over serial.

Table 12.2: Menu Commands	
12 Calibrate DSP clock	Performs DSP clock calibration.
13 Exit	Logs off as Maintenance user.

Table 12.3: Network Utilities Menu Commands	
View protocol statistics	View IP, TCP and UDP statistics.
View active socket states	View current states of active sockets.
View routing tables	View routing tables.
View MAC address	View MAC address.
Flush gateway entries	Flush the routing tables of all gateway entries.
Ping	Check network connection to given point.
Enable/disable packet forwarding	Enable or disable TCP packets forwarding.
Exit network utilities	Exit network utilities menu and return to maintenance menu commands.

12.2 Error Handling

The device has hardware and software self-check capabilities that work to keep it operational and provide an indication if a failure occurs.

Failure Contact

Output Contact #1 on the rear panel is a normally closed contact that closes to indicate a problem with the device. The contact is controlled by a hardware watchdog circuit, ensuring a failure is reported even if the unit's processors are not functional. The state of the Failure Contact is mirrored by the front panel Recorder Functional LED.

Failure Handling

Supervisory software continually checks all system processes. If a failure is detected an attempt is made to correct the problem through a software restart. A software restart takes place quickly and does not activate any external indicators.

If the failure persists, the unit will initiate a hardware reset to attempt to clear the problem. A hardware reset takes approximately a minute and half to complete. If the problem is not cleared after four consecutive reset attempts, the unit enters the Persistent Error state. In this state, the unit activates its failure indicators and stops initiating resets to avoid interfering with any diagnostic investigation.

If the Supervisory software subsequently determines that the problem has been cleared, it automatically returns the unit to its normal operating state, clearing the failure indicators.

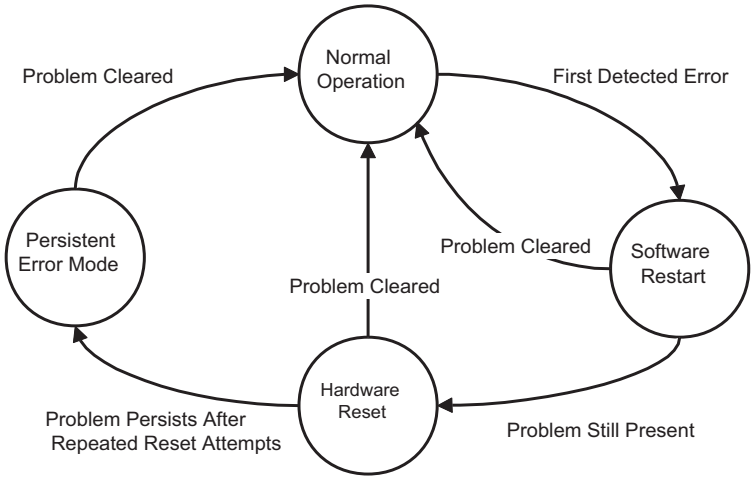


Figure 12.2: Error Handling

State Indicators

Table 12.4: State Indicators	
Device State	Indicators
Normal	Unit Functional LED ON Failure Contact OPEN
Software Reset	Unit Functional LED ON Failure Contact OPEN
Hardware Reset	Unit Functional LED ON Test Mode LED ON Failure Contact OPEN
Persistent Error	Unit Functional LED OFF Alarm LED ON Failure Contact CLOSED

Diagnostic Tools

The device has an internal log file to aid in problem diagnosis. The log can be viewed from the Maintenance Menu (see below). As well, a full diagnostic information package can be generated and uploaded to your PC, where it can be e-mailed to ERLPhase customer support for analysis.

The Maintenance menu also has tools to help diagnose SCADA problems and network communication problems.

Appendix A Specifications

ERL Digital I/O Expansion Module

Item	Quantity/Specs	Notes
General		
Weight	20.2 lbs (9.2 kg)	
Dimensions	4U high (7.00"), 19" wide, 12.725" deep	Rack mount
Nominal Frequency	50 or 60 Hz	
Power Supply	38 – 300 Vdc, 90 – 265 Vac	Maximum current: 0.7 A Maximum burden: 35 W
Sample Rate	96 samples/cycle (s/c)	
Recording and Logging		
Transient Fault	Record Length 0.2 to 15 seconds, 30 second extended	
Record Storage	Up to 150 records	
Event Logging	500 events in the regular log	
Channels and Triggers		
GOOSE Virtual Inputs (digital)	Active, Inactive or both	
Interface & Communication		
Front Panel Indicators	6 LEDs	Unit Functional, IRIG-B Functional, Test Mode, Alarm 1, Alarm 2, Alarm 3
Front User Interfaces	USB port and 100BASE-T Ethernet port	
Rear User Interfaces	LAN Ports: Copper, Optical (ST) style connector	Copper: RJ-45, 100BASE-T Optical (ST): 100BASE-FX, Multimode, 1300 nm, ST
Serial User Interface	Serial RS-232 port to 115 kbd	
SCADA Interface	DNP3 or Modbus	Ethernet: DNP3 RS: 232: DNP3 or Modbus
Self Checking/Recorder Inoperative	1 contact (#1)	Normally closed
Time Sync	IRIG-B, B003,B004,B123 and B124 Time Codes	Input: - modulated or unmodulated Outputs: - Retransmits valid IRIG input - Transmits unmodulated IRIG-B using internal real time clock as the reference when IRIG-B input is invalid.
Inputs and Outputs		

ERL Digital I/O Expansion Module		
External Inputs (digital)	Will turn on: >= 38 Vdc Will not turn on: <= 25Vdc Maximum input: < 300Vdc Burden: > 10 kilo-ohm	128 per unit Externally wetted
Alarm Contacts	300 Vdc max, externally wetted Make: 8 A Vdc Carry: 8 A Vdc Break: 0.15 A at 125 Vdc 0.10 A at 250 Vdc	16 per unit Contact #1: Unit Functional User-definable contacts – Pick-up <1.0 s, latch 1.0 s
Environmental		
Ambient Temperature Range	IEC 60068-2-1/IEC 60068-2-2	-40°C to 85 °C
Humidity	IEC 60068-2-30	Up to 95% without condensation
Insulation Test (Hi-Pot)	IEC 60255-5	Power supply, external inputs, output contacts – 2 kV, 50/60 Hz, 1 minute
Electrostatic Discharge	IEC 61000-4-2 Level 4, IEEE C37.90.3, IEC 60255-22-2 Level 4	
Voltage Dips, Interruptions, Variations	IEC 6100-4-11, IEC 60255-11	200 ms Interrupt
Conducted RF Immunity	IEC 61000-4-6 Level 3, IEC 60255-22-6 Level 3[2]	
Radiated RF Susceptibility	IEC 61000-4-6 Level 3, IEC 60255-22-3 Level 3	
Electrical Fast Transient/ Burst	IEC 61000-4-4 Level 4 (4 kV), IEC 60255-22-4 Class IV (4 kV)[3]	
Oscillatory Transient	ANSI/IEEE C37.90.1-1989, IEC 61000-4-12 Level 3, IEC 60255-22-1 Level 3	
Oscillatory Vibration	IEC 60068-2-6, IEC 60255-21-1 Class 1	
Seismic	IEC 60068-3-3, IEC 60255-21-3 Class 1	
Shock and Bump	IEC 60255-21-2 Class 1	
RF Emissions	IEC/EN 60255-25 Class A[4]	
Conducted Emissions	IEC/EN 60255-25 Class A[4]	

ERL Digital I/O Expansion Module

Detailed Environmental Tests

Test	Description		Test Level
	Type Test	Test Points	
IEC/EN 60068-2-1	Cold Temperature	N/A	-40°C for 16 hours

ERL Digital I/O Expansion Module

Detailed Environmental Tests

IEC/EN 60068-2-2	Hot Temperature	N/A	-85°C for 16 hours
IEC/EN 60068-2-30	Humidity Cycle	N/A	55°C/93% RH and 25°C/95% RH, 12 hours at each level
IEC/EN 60255-21-1 IEC/EN 60068-2-6	Sinusoidal Vibration Class 1	N/A	1 g, 10 to 150 Hz, 20 sweeps per axis
IEC/EN 60255-21-2 IEC/EN 60068-2-27 IEC/EN 60068-2-29	Shock	N/A	15 g, 11 ms duration, 6 per axis
	Bump	N/A	10 g, 16 ms duration, 1000 per axis
IEC/EN 60255-21-3: Class 1; IEC/EN 60068-3-3: Class 1	Seismic	N/A	1g's from 5 – 35 Hz on each axis
FCC Part 15	RF Emissions	N/A	Class A: 30-1000 MHz
	Conducted Emissions	Power Port	Class A: 0.15-30 MHz
IEC/EN 60255-25	RF Emissions	N/A	Class A: 30-2000 MHz
	Conducted Emissions	Power Port	Class A: 0.15-30 MHz
IEC/EN 61000-4-2 IEC/EN 60255-22-2 IEEE C37.90.3	ESD (Direct and Indirect)	Enclosure Contact	+/- 8 kV
		Enclosure Air	+/- 15 kV
IEC/EN 61000-4-3 IEC/EN 60255-22-3	Radiated RFI – Modulated	Enclosure Ports	10V/m: 80 – 1000 MHz
IEEE C37.90.2 IEC/EN 61000-4-3	Radiated RFI – Unmodulated	Enclosure Ports	35 V/m: 25 – 1000 MHz
IEC/EN 61000-4-4 IEC/EN 60255-22-4 IEEE C37.90.1	Burst (Fast Transient)	Enclosure Ports	+/- 4 kV
IEC/EN 61000-4-5 IEC/EN 60255-22-5	Surge	Communication Ports	+/- 1 kV L-PE
		Signal Ports	+/- 2 kV L-PE, +/-1 kV L-L
		Power Port	+/- 4kV L-PE, +/-2 kV L-L
IEC/EN 61000-4-6 IEC/EN 60255-22-6	Induced (Conducted) RFI	Enclosure Ports	10 Vrms: 0.150 – 80 MHz
IEC/EN 60255-22-7	Power Frequency	Binary Input Ports: Class A	Differential = 150 Vrms Common = 300 Vrms
IEC/EN 61000-4-8	Magnetic Field	Enclosure Ports	40 A/m continuous, 1000 A/m for 60 s
IEC/EN 61000-4-11 IEC/EN 61000-4-29	Voltage Dips & Interrupts	Power Port – AC applied	40% for 10/12 cycles, 70% for 10/12 cycles, 100% for 250/300 cycles
IEC 60255-11	Voltage Dips & Interrupts	Power Port – DC applied	100% reduction for up to 200 ms
IEC 60255-26	Dielectric Strength Insulation	Signal and Power Ports	+/- 2 kV for 1 minute

ERL Digital I/O Expansion Module			
Detailed Environmental Tests			
IEC 60255-27	Impulse Immunity	Communication Ports	+/- 1 kV 8/20μs impulse to ground
		Non-communication Ports	+/- 5 kV 8/20μs impulse to ground
IEC/EN 61000-4-12 IEC/EN 60255-22-1 IEEE C37.90.1	Oscillatory	Enclosure Ports	2.5 kV
IEC/EN 61000-4-16	Mains Frequency Voltage	Signal Ports	30 V continuous, 300 V for 1s
		DC Power Port	30 V continuous, 300 V for 1s
IEC/EN 61000-4-17		DC Power Port	10%

Appendix B Hardware Description

The ERL I/O Expansion is a digital expansion device designed to interface with power systems status inputs for communications in IEC 61850 GOOSE format. Unit output contact status is also controlled via GOOSE messaging. The following information describes the main hardware components of the unit:

Main Processor Board

The Main Processor Board consists of a DSP, a power PC processor, serial ports, Ethernet ports, an IRIG-B processor, a watchdog and a power supply that supplies the other boards. All other boards are connected to the MPB as I/O.

The MPB has two processor sub-systems which control the operation of the entire device: the DSP processor and the control processor. The DSP sub-system interfaces to the DIB and the OCB and manages the protection features of the relay. The control processor manages the user interface and system control features of the relay. Both subsystems operate independently of each other and will continue to function even if the other sub-system fails.

The MPB provides the following functionality:

- DSP processor subsystem which interfaces to the DIB with:
  - The floating point DSP to provide fast capture and manipulation of data.
  - RAM and reprogrammable non-volatile Flash memory. Allows operation independent of the control processor and supports field software updates.
- A control processor subsystem which manages the user interface and system control features of the relay, with
  - RAM and reprogrammable non-volatile Flash memory. Allows operation independent of the DSP processor and supports field software upgrades.
  - Settings and recordings stored in non-volatile memory.
  - Runs a Real Time Operating System (RTOS).
  - Provides Ethernet ports and RS-232 ports for SCADA and USB interfaces.
- A time synchronism processor with automatic detection of modulated and un-modulated IRIG-B
- A high speed link is provided between the DSP and control processor subsystems.
- Sophisticated fault detection and ?watchdog? recovery hardware
- The MPB also provides the power supply for the entire unit. The power supply operating range is 48-250 Vdc, 100-240 Vac, +/-10%, 50/60 Hz.

This wide operating range provides easier installation by eliminating power supply ordering options

External Input Boards

The ERL I/O Expansion Unit has 32 external inputs and 4 contact outputs provided by each External Input Board. Inputs are optically isolated and accept up to 300 Vdc. Four external input boards combine for a total of 128 external inputs and 16 outputs. Rear panel connection to the board is provided by removable screw terminal strips. Terminal strips are keyed to ensure that the correct terminal strip is installed into the correct bank.

Comm Board

The enhanced Comm Board (ERPCB) provides the ERL I/O Expansion unit with two Ethernet ports (RJ-45 or ST optical), an RS-232 SCADA Port (DB-9) and an IRIG-B time synchronization input (modulated or unmodulated) as a 2-wire input. The ERPCB is also capable of providing five local time synchronization outputs (IRIG-B format), each as a separate 2-wire output. An additional five RJ-45 Ethernet ports are available on the ERPCB, which are mapped via an Ethernet switch to either the port 401 or port 402 subnets.

Power Supply

The Power Supply conditions and converts the input power for use by the internal electronics. The wide input voltage provides the TESLA with the ability to operate from 48 to 250 Vdc or 100-240 Vac +/-10%.

Front Panel Board

The Front Panel Board provides visual indication of the status of the IO Expansion and USB and network ports.

Appendix C Glossary

	These modules can be connected to any of the Analog Input terminals on TESLA
COMTRADE	Common Format for Transient Data Exchange. IEEE standard C37.111-1991, IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems, which describes a common format for exchange of recorded power systems data between different manufacturers' recorders.
DCE	Data Communications Equipment, an RS-232 term for SCADA and similar equipment. DCEs generally have a female DB connector.
DST	Daylight Savings Time. A seasonal adjustment of time applied in many jurisdictions to compensate for varying day lengths. Most often, an hour is added to the system time to begin on the second Sunday in March and end the first Sunday in November.
DTE	Data Terminal Equipment, an RS-232 term for a terminal or computer. DTEs generally have a male DB connector.
DUN	Dial-Up Networking, a facility in Windows providing dial-up access to Internet and other networks. DUN is provided with the Windows distribution.
EIA RS-232C	Electronics Industries Association recommended standard 232, revision C, Interface between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange. Defines the most popular electrical connection for serial binary data interchange, available on almost all computer systems.
External Input	A contact status brought into TESLA from the outside world. This contact must be externally wetted with a voltage from 30 to 150 Vdc. Correct polarity must be observed.
GOOSE	Generic Object Oriented Substation Events. A protocol contained within the IEC 61850 standard for communication in substation automation applications.
IEC 61850	A standard developed through the International Electrotechnical Commission related to the architecture of electric power systems, specifically the design of electrical substation automation.
IED	Intelligent Electronic Device, referring to a power system substation device which communications on a substation network, such as Modbus.
IEEE 1344	IEEE 1344 is an enhancement to the basic IRIG-B time code that embeds information such as the year, the UTC/local offset (under certain conditions only) and daylight savings time into the time stream. IEEE standard 1344-95, IEEE Standard for Synchrophasors for Power Systems, outlines the implementation and use of accurate time standards for power systems relaying and recording. Annex F describes an IRIG-B extension (using previously unused control bits in the signal) which provides extensive information beyond that of standard IRIG-B.
IEEE C37.232	An IEEE standard related to the procedure for the naming of Time Sequence Data (TSD) files produced by digital fault recorders in power systems applications.
IRIG-B	Inter-Range Instrumentation Group time code format type B, see Range Commanders Council Telecommunications and Timing Group, IRIG standard 200-95, IRIG Serial Time Code Formats. Describes an implementation for distribution of precise timing information, especially to power systems relays and recorders. IRIG-B is typically provided by a satellite clock (e.g. GPS or GOES).
Modbus	Modbus is a network using a master/slave protocol often used in power system substations. Its function was developed and is defined by Modicon, Inc., North Andover, MA, USA. Refer to Modbus Protocol Reference Guide, Modicon document PI-MBUS-300.
PTI	Power Technologies Incorporated
SFP	The small form-factor pluggable (SFP) is a compact, pluggable optical transceiver used for networking applications.

SNTP	Simple Network Time Protocol. A simplified version of Network Time Protocol (NTP) use for synchronizing devices and equipment to a common, network based time source in the form of an SNTP server. SNTP time synchronization is not recommended in application where time accuracy is required.
UTC	Universally Coordinated Time. Approximately equivalent to Greenwich Mean Time (GMT). A universal time maintained by time standards bodies worldwide. All local times are expressed as an offset from UTC.

Appendix D Modbus RTU Communication Protocol

Metering values available through the Control Panel are also available via the Modbus protocol. Additionally the Modbus protocol supports the reading of unit time and time of the readings and provides access to trip and alarm events. All metering readings can be frozen into a snapshot via the “Hold Readings” function (see Force Single Coil function, address 0).

Table D.1: Read Coil Status (Function Code 01)

Channel	Address	Values	
Hold Readings	1	0: Readings not held	1: Readings held
Reserved	257	Reserved	Reserved
Output Contact 1	513	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 2	514	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 3	515	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 4	516	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 5	517	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 6	518	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 7	519	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 8	520	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 9	521	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 10	522	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 11	523	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 12	524	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 13	525	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 14	526	0: Contact Open (inactive)	1: Contact Closed (active)
Output Contact 15	527	0: Contact Open (inactive)	1: Contact Closed (active)

Table D.2: Read Input Status (Function Code 02)			
Channel	Address	Values	
External Input 1	10001	0: Off (inactive)	1: On (active)
External Input 2	10002	0: Off (inactive)	1: On (active)
External Input 3	10003	0: Off (inactive)	1: On (active)
External Input 4	10004	0: Off (inactive)	1: On (active)
External Input 5	10005	0: Off (inactive)	1: On (active)
External Input 6	10006	0: Off (inactive)	1: On (active)
External Input 7	10007	0: Off (inactive)	1: On (active)
External Input 8	10008	0: Off (inactive)	1: On (active)
External Input 9	10009	0: Off (inactive)	1: On (active)
External Input 10	10010	0: Off (inactive)	1: On (active)
External Input 11	10011	0: Off (inactive)	1: On (active)
External Input 12	10012	0: Off (inactive)	1: On (active)
External Input 13	10013	0: Off (inactive)	1: On (active)
External Input 14	10014	0: Off (inactive)	1: On (active)
External Input 15	10015	0: Off (inactive)	1: On (active)
External Input 16	10016	0: Off (inactive)	1: On (active)
External Input 17	10017	0: Off (inactive)	1: On (active)
External Input 18	10018	0: Off (inactive)	1: On (active)
External Input 19	10019	0: Off (inactive)	1: On (active)
External Input 20	10020	0: Off (inactive)	1: On (active)
External Input 21	10021	0: Off (inactive)	1: On (active)
External Input 22	10022	0: Off (inactive)	1: On (active)
External Input 23	10023	0: Off (inactive)	1: On (active)
External Input 24	10024	0: Off (inactive)	1: On (active)
External Input 25	10025	0: Off (inactive)	1: On (active)
External Input 26	10026	0: Off (inactive)	1: On (active)
External Input 27	10027	0: Off (inactive)	1: On (active)
External Input 28	10028	0: Off (inactive)	1: On (active)
External Input 29	10029	0: Off (inactive)	1: On (active)
External Input 30	10030	0: Off (inactive)	1: On (active)
External Input 31	10031	0: Off (inactive)	1: On (active)
External Input 32	10032	0: Off (inactive)	1: On (active)

Table D.2: Read Input Status (Function Code 02)			
Channel	Address	Values	
External Input 33	10033	0: Off (inactive)	1: On (active)
External Input 34	10034	0: Off (inactive)	1: On (active)
External Input 35	10035	0: Off (inactive)	1: On (active)
External Input 36	10036	0: Off (inactive)	1: On (active)
External Input 37	10037	0: Off (inactive)	1: On (active)
External Input 38	10038	0: Off (inactive)	1: On (active)
External Input 39	10039	0: Off (inactive)	1: On (active)
External Input 40	10040	0: Off (inactive)	1: On (active)
External Input 41	10041	0: Off (inactive)	1: On (active)
External Input 42	10042	0: Off (inactive)	1: On (active)
External Input 43	10043	0: Off (inactive)	1: On (active)
External Input 44	10044	0: Off (inactive)	1: On (active)
External Input 45	10045	0: Off (inactive)	1: On (active)
External Input 46	10046	0: Off (inactive)	1: On (active)
External Input 47	10047	0: Off (inactive)	1: On (active)
External Input 48	10048	0: Off (inactive)	1: On (active)
External Input 49	10049	0: Off (inactive)	1: On (active)
External Input 50	10050	0: Off (inactive)	1: On (active)
External Input 51	10051	0: Off (inactive)	1: On (active)
External Input 52	10052	0: Off (inactive)	1: On (active)
External Input 53	10053	0: Off (inactive)	1: On (active)
External Input 54	10054	0: Off (inactive)	1: On (active)
External Input 55	10055	0: Off (inactive)	1: On (active)
External Input 56	10056	0: Off (inactive)	1: On (active)
External Input 57	10057	0: Off (inactive)	1: On (active)
External Input 58	10058	0: Off (inactive)	1: On (active)
External Input 59	10059	0: Off (inactive)	1: On (active)
External Input 60	10060	0: Off (inactive)	1: On (active)
External Input 61	10061	0: Off (inactive)	1: On (active)
External Input 62	10062	0: Off (inactive)	1: On (active)
External Input 63	10063	0: Off (inactive)	1: On (active)
External Input 64	10064	0: Off (inactive)	1: On (active)
External Input 65	10065	0: Off (inactive)	1: On (active)

Table D.2: Read Input Status (Function Code 02)			
Channel	Address	Values	
External Input 66	10066	0: Off (inactive)	1: On (active)
External Input 67	10067	0: Off (inactive)	1: On (active)
External Input 68	10068	0: Off (inactive)	1: On (active)
External Input 69	10069	0: Off (inactive)	1: On (active)
External Input 70	10070	0: Off (inactive)	1: On (active)
External Input 71	10071	0: Off (inactive)	1: On (active)
External Input 72	10072	0: Off (inactive)	1: On (active)
External Input 73	10073	0: Off (inactive)	1: On (active)
External Input 74	10074	0: Off (inactive)	1: On (active)
External Input 75	10075	0: Off (inactive)	1: On (active)
External Input 76	10076	0: Off (inactive)	1: On (active)
External Input 77	10077	0: Off (inactive)	1: On (active)
External Input 78	10078	0: Off (inactive)	1: On (active)
External Input 79	10079	0: Off (inactive)	1: On (active)
External Input 80	10080	0: Off (inactive)	1: On (active)
External Input 81	10081	0: Off (inactive)	1: On (active)
External Input 82	10082	0: Off (inactive)	1: On (active)
External Input 83	10083	0: Off (inactive)	1: On (active)
External Input 84	10084	0: Off (inactive)	1: On (active)
External Input 85	10085	0: Off (inactive)	1: On (active)
External Input 86	10086	0: Off (inactive)	1: On (active)
External Input 87	10087	0: Off (inactive)	1: On (active)
External Input 88	10088	0: Off (inactive)	1: On (active)
External Input 89	10089	0: Off (inactive)	1: On (active)
External Input 90	10090	0: Off (inactive)	1: On (active)
External Input 91	10091	0: Off (inactive)	1: On (active)
External Input 92	10092	0: Off (inactive)	1: On (active)
External Input 93	10093	0: Off (inactive)	1: On (active)
External Input 94	10094	0: Off (inactive)	1: On (active)
External Input 95	10095	0: Off (inactive)	1: On (active)
External Input 96	10096	0: Off (inactive)	1: On (active)
External Input 97	10097	0: Off (inactive)	1: On (active)
External Input 98	10098	0: Off (inactive)	1: On (active)

Table D.2: Read Input Status (Function Code 02)			
Channel	Address	Values	
External Input 99	10099	0: Off (inactive)	1: On (active)
External Input 100	10100	0: Off (inactive)	1: On (active)
External Input 101	10101	0: Off (inactive)	1: On (active)
External Input 102	10102	0: Off (inactive)	1: On (active)
External Input 103	10103	0: Off (inactive)	1: On (active)
External Input 104	10104	0: Off (inactive)	1: On (active)
External Input 105	10105	0: Off (inactive)	1: On (active)
External Input 106	10106	0: Off (inactive)	1: On (active)
External Input 107	10107	0: Off (inactive)	1: On (active)
External Input 108	10108	0: Off (inactive)	1: On (active)
External Input 109	10109	0: Off (inactive)	1: On (active)
External Input 110	10110	0: Off (inactive)	1: On (active)
External Input 111	10111	0: Off (inactive)	1: On (active)
External Input 112	10112	0: Off (inactive)	1: On (active)
External Input 113	10113	0: Off (inactive)	1: On (active)
External Input 114	10114	0: Off (inactive)	1: On (active)
External Input 115	10115	0: Off (inactive)	1: On (active)
External Input 116	10116	0: Off (inactive)	1: On (active)
External Input 117	10117	0: Off (inactive)	1: On (active)
External Input 118	10118	0: Off (inactive)	1: On (active)
External Input 119	10119	0: Off (inactive)	1: On (active)
External Input 120	10120	0: Off (inactive)	1: On (active)
External Input 121	10121	0: Off (inactive)	1: On (active)
External Input 122	10122	0: Off (inactive)	1: On (active)
External Input 123	10123	0: Off (inactive)	1: On (active)
External Input 124	10124	0: Off (inactive)	1: On (active)
External Input 125	10125	0: Off (inactive)	1: On (active)
External Input 126	10126	0: Off (inactive)	1: On (active)
External Input 127	10127	0: Off (inactive)	1: On (active)
External Input 128	10128	0: Off (inactive)	1: On (active)
External Input 1 Change of state latch	10257	0: Off (inactive)	1: On (active)
External Input 2 Change of state latch	10258	0: Off (inactive)	1: On (active)
External Input 3 Change of state latch	10259	0: Off (inactive)	1: On (active)

Table D.2: Read Input Status (Function Code 02)			
Channel	Address	Values	
External Input 4 Change of state latch	10260	0: Off (inactive)	1: On (active)
External Input 5 Change of state latch	10261	0: Off (inactive)	1: On (active)
External Input 6 Change of state latch	10262	0: Off (inactive)	1: On (active)
External Input 7 Change of state latch	10263	0: Off (inactive)	1: On (active)
External Input 8 Change of state latch	10264	0: Off (inactive)	1: On (active)
External Input 9 Change of state latch	10265	0: Off (inactive)	1: On (active)
External Input 10 Change of state latch	10266	0: Off (inactive)	1: On (active)
External Input 11 Change of state latch	10267	0: Off (inactive)	1: On (active)
External Input 12 Change of state latch	10268	0: Off (inactive)	1: On (active)
External Input 13 Change of state latch	10269	0: Off (inactive)	1: On (active)
External Input 14 Change of state latch	10270	0: Off (inactive)	1: On (active)
External Input 15 Change of state latch	10271	0: Off (inactive)	1: On (active)
External Input 16 Change of state latch	10272	0: Off (inactive)	1: On (active)
External Input 17 Change of state latch	10273	0: Off (inactive)	1: On (active)
External Input 18 Change of state latch	10274	0: Off (inactive)	1: On (active)
External Input 19 Change of state latch	10275	0: Off (inactive)	1: On (active)
External Input 20 Change of state latch	10276	0: Off (inactive)	1: On (active)
External Input 21 Change of state latch	10277	0: Off (inactive)	1: On (active)
External Input 22 Change of state latch	10278	0: Off (inactive)	1: On (active)
External Input 23 Change of state latch	10279	0: Off (inactive)	1: On (active)
External Input 24 Change of state latch	10280	0: Off (inactive)	1: On (active)
External Input 25 Change of state latch	10281	0: Off (inactive)	1: On (active)
External Input 26 Change of state latch	10282	0: Off (inactive)	1: On (active)
External Input 27 Change of state latch	10283	0: Off (inactive)	1: On (active)
External Input 28 Change of state latch	10284	0: Off (inactive)	1: On (active)
External Input 29 Change of state latch	10285	0: Off (inactive)	1: On (active)
External Input 30 Change of state latch	10286	0: Off (inactive)	1: On (active)
External Input 31 Change of state latch	10287	0: Off (inactive)	1: On (active)
External Input 32 Change of state latch	10288	0: Off (inactive)	1: On (active)
External Input 33 Change of state latch	10289	0: Off (inactive)	1: On (active)
External Input 34 Change of state latch	10290	0: Off (inactive)	1: On (active)
External Input 35 Change of state latch	10291	0: Off (inactive)	1: On (active)
External Input 36 Change of state latch	10292	0: Off (inactive)	1: On (active)

Table D.2: Read Input Status (Function Code 02)			
Channel	Address	Values	
External Input 37 Change of state latch	10293	0: Off (inactive)	1: On (active)
External Input 38 Change of state latch	10294	0: Off (inactive)	1: On (active)
External Input 39 Change of state latch	10295	0: Off (inactive)	1: On (active)
External Input 40 Change of state latch	10296	0: Off (inactive)	1: On (active)
External Input 41 Change of state latch	10297	0: Off (inactive)	1: On (active)
External Input 42 Change of state latch	10298	0: Off (inactive)	1: On (active)
External Input 43 Change of state latch	10299	0: Off (inactive)	1: On (active)
External Input 44 Change of state latch	10300	0: Off (inactive)	1: On (active)
External Input 45 Change of state latch	10301	0: Off (inactive)	1: On (active)
External Input 46 Change of state latch	10302	0: Off (inactive)	1: On (active)
External Input 47 Change of state latch	10303	0: Off (inactive)	1: On (active)
External Input 48 Change of state latch	10304	0: Off (inactive)	1: On (active)
External Input 49 Change of state latch	10305	0: Off (inactive)	1: On (active)
External Input 50 Change of state latch	10306	0: Off (inactive)	1: On (active)
External Input 51 Change of state latch	10307	0: Off (inactive)	1: On (active)
External Input 52 Change of state latch	10308	0: Off (inactive)	1: On (active)
External Input 53 Change of state latch	10309	0: Off (inactive)	1: On (active)
External Input 54 Change of state latch	10310	0: Off (inactive)	1: On (active)
External Input 55 Change of state latch	10311	0: Off (inactive)	1: On (active)
External Input 56 Change of state latch	10312	0: Off (inactive)	1: On (active)
External Input 57 Change of state latch	10313	0: Off (inactive)	1: On (active)
External Input 58 Change of state latch	10314	0: Off (inactive)	1: On (active)
External Input 59 Change of state latch	10315	0: Off (inactive)	1: On (active)
External Input 60 Change of state latch	10316	0: Off (inactive)	1: On (active)
External Input 61 Change of state latch	10317	0: Off (inactive)	1: On (active)
External Input 62 Change of state latch	10318	0: Off (inactive)	1: On (active)
External Input 63 Change of state latch	10319	0: Off (inactive)	1: On (active)
External Input 64 Change of state latch	10320	0: Off (inactive)	1: On (active)
External Input 65 Change of state latch	10321	0: Off (inactive)	1: On (active)
External Input 66 Change of state latch	10322	0: Off (inactive)	1: On (active)
External Input 67 Change of state latch	10323	0: Off (inactive)	1: On (active)
External Input 68 Change of state latch	10324	0: Off (inactive)	1: On (active)
External Input 69 Change of state latch	10325	0: Off (inactive)	1: On (active)

Table D.2: Read Input Status (Function Code 02)			
Channel	Address	Values	
External Input 70 Change of state latch	10326	0: Off (inactive)	1: On (active)
External Input 71 Change of state latch	10327	0: Off (inactive)	1: On (active)
External Input 72 Change of state latch	10328	0: Off (inactive)	1: On (active)
External Input 73 Change of state latch	10329	0: Off (inactive)	1: On (active)
External Input 74 Change of state latch	10330	0: Off (inactive)	1: On (active)
External Input 75 Change of state latch	10331	0: Off (inactive)	1: On (active)
External Input 76 Change of state latch	10332	0: Off (inactive)	1: On (active)
External Input 77 Change of state latch	10333	0: Off (inactive)	1: On (active)
External Input 78 Change of state latch	10334	0: Off (inactive)	1: On (active)
External Input 79 Change of state latch	10335	0: Off (inactive)	1: On (active)
External Input 80 Change of state latch	10336	0: Off (inactive)	1: On (active)
External Input 81 Change of state latch	10337	0: Off (inactive)	1: On (active)
External Input 82 Change of state latch	10338	0: Off (inactive)	1: On (active)
External Input 83 Change of state latch	10339	0: Off (inactive)	1: On (active)
External Input 84 Change of state latch	10340	0: Off (inactive)	1: On (active)
External Input 85 Change of state latch	10341	0: Off (inactive)	1: On (active)
External Input 86 Change of state latch	10342	0: Off (inactive)	1: On (active)
External Input 87 Change of state latch	10343	0: Off (inactive)	1: On (active)
External Input 88 Change of state latch	10344	0: Off (inactive)	1: On (active)
External Input 89 Change of state latch	10345	0: Off (inactive)	1: On (active)
External Input 90 Change of state latch	10346	0: Off (inactive)	1: On (active)
External Input 91 Change of state latch	10347	0: Off (inactive)	1: On (active)
External Input 92 Change of state latch	10348	0: Off (inactive)	1: On (active)
External Input 93 Change of state latch	10349	0: Off (inactive)	1: On (active)
External Input 94 Change of state latch	10350	0: Off (inactive)	1: On (active)
External Input 95 Change of state latch	10351	0: Off (inactive)	1: On (active)
External Input 96 Change of state latch	10352	0: Off (inactive)	1: On (active)
External Input 97 Change of state latch	10353	0: Off (inactive)	1: On (active)
External Input 98 Change of state latch	10354	0: Off (inactive)	1: On (active)
External Input 99 Change of state latch	10355	0: Off (inactive)	1: On (active)
External Input 100 Change of state latch	10356	0: Off (inactive)	1: On (active)
External Input 101 Change of state latch	10357	0: Off (inactive)	1: On (active)
External Input 102 Change of state latch	10358	0: Off (inactive)	1: On (active)

Table D.2: Read Input Status (Function Code 02)			
Channel	Address	Values	
External Input 103 Change of state latch	10359	0: Off (inactive)	1: On (active)
External Input 104 Change of state latch	10360	0: Off (inactive)	1: On (active)
External Input 105 Change of state latch	10361	0: Off (inactive)	1: On (active)
External Input 106 Change of state latch	10362	0: Off (inactive)	1: On (active)
External Input 107 Change of state latch	10363	0: Off (inactive)	1: On (active)
External Input 108 Change of state latch	10364	0: Off (inactive)	1: On (active)
External Input 109 Change of state latch	10365	0: Off (inactive)	1: On (active)
External Input 110 Change of state latch	10366	0: Off (inactive)	1: On (active)
External Input 111 Change of state latch	10367	0: Off (inactive)	1: On (active)
External Input 112 Change of state latch	10368	0: Off (inactive)	1: On (active)
External Input 113 Change of state latch	10369	0: Off (inactive)	1: On (active)
External Input 114 Change of state latch	10370	0: Off (inactive)	1: On (active)
External Input 115 Change of state latch	10371	0: Off (inactive)	1: On (active)
External Input 116 Change of state latch	10372	0: Off (inactive)	1: On (active)
External Input 117 Change of state latch	10373	0: Off (inactive)	1: On (active)
External Input 118 Change of state latch	10374	0: Off (inactive)	1: On (active)
External Input 119 Change of state latch	10375	0: Off (inactive)	1: On (active)
External Input 120 Change of state latch	10376	0: Off (inactive)	1: On (active)
External Input 121 Change of state latch	10377	0: Off (inactive)	1: On (active)
External Input 122 Change of state latch	10378	0: Off (inactive)	1: On (active)
External Input 123 Change of state latch	10379	0: Off (inactive)	1: On (active)
External Input 124 Change of state latch	10380	0: Off (inactive)	1: On (active)
External Input 125 Change of state latch	10381	0: Off (inactive)	1: On (active)
External Input 126 Change of state latch	10382	0: Off (inactive)	1: On (active)
External Input 127 Change of state latch	10383	0: Off (inactive)	1: On (active)
External Input 128 Change of state latch	10384	0: Off (inactive)	1: On (active)

Table D.3: Read Holding Registers (Function Code 03)			
Channel	Address	Values	Scale
IED Clock Time (UTC). Read all in same query to ensure consistent time reading data			
Milliseconds	40001	0 – 999	1
Seconds	40002	0 – 59	1
Minutes	40003	0 – 59	1
Hours	40004	0 – 23	1
Day of Year	40005	1 – 365 (366 for leap years)	1
Year since 1900	40006	115 – 137	1
Synchronized to IRIGB	40007	0: No, 1: Yes	1
Time of Acquisition (UTC). Read all in same query to ensure consistent time reading data			
Milliseconds	40008	0 – 999	1
Seconds	40009	0 – 59	1
Minutes	40010	0 – 59	1
Hours	40011	0 – 23	1
Day of Year	40012	1 – 365 (366 for leap years)	1
Year since 1900	40013	115 – 137	1
Synchronized to IRIG-B	40014	0: No, 1: Yes	1
Offset of UTC to IED Time	40015	Zone's complement half hours. North America is negative	1

Table D.4: Read Holding Registers (Function Code 04)
No input registers supported. Response from IED indicates "ILLEGAL FUNCTION".

Table D.5: Force Single Coil (Function Code 05)

Only the “Hold Readings” coil can be forced. When active, this coil locks all coil, input and holding register readings simultaneously at their most recent available state.

Channel	Type	Address	Value
Hold Readings	Read/Write	01	0000: Readings updated normally (inactive) FF00: Hold readings (active)

Table D.6: Preset Single Register (Function Code 06)

Event Message Control (See below for details of use).

Channel	Address	Value	Scale
Refresh event list	40257	No data required	N/A
Acknowledge the current event and get the next event	40258	No data required	N/A
Get the next event (without acknowledge)	40259	No data required	N/A
Event Buffer Size		100 events	

Table D.7: Diagnostic Subfunctions (Function Code 08)

Return Query Data (Subfunction 00)	This provides an echo of the submitted message
Restart Comm. Option (Subfunction 01)	This restarts the Modbus communications process.
Force Listen Only Mode (Subfunction 04)	No response is returned. IED enters “Listen Only” mode. This mode can only be exited by the “Restart Comm. Option” command.

Table D.8: Report Slave ID (Function Code 17 (Hex 11))			
A fixed response is returned by the IED, including system model, version and issue numbers.			
Channel	**Type**	**Bytes**	**Value**
Model Number	Read Only	0 and 1	0xFA4 = 4004 decimal
Version Number	Read Only	2 and 3	Version number
Issue Number	Read Only	4 and 5	Issue number

- The IO Expansion model number is 4004.
- Version and issue will each be positive integers, say X and Y.
- The IO Expansion is defined as “Model 4004, Version X Issue Y”.

Table D.9: Accessing IO Expansion Event Information	
All IO Expansion detector event messages displayed in the Event Log are available via Modbus. The following controls are available.	
Refresh Event List	(Function Code 6, address 40257): Fetches the latest events from the relay's event log and makes them available for Modbus access. The most recent event becomes the current event available for reading.
Acknowledge Current Event and Get Next Event	(Function Code 6, address 40258): Clears the current event from the read registers and places the next event into the read registers. An acknowledged event is no longer available for reading.
Get Next Event	(Function Code 6, address 40259): Places the next event in the read registers without acknowledging the current event. The current event will reappear in the list when the function Refresh Event List is used.
Size of Current Event Message	(Function Code 3, address 40260): Indicates the number of 16 bit registers used to contain the current event. Event data is stored with 2 characters per register. A reading of zero indicates that there are no unacknowledged events available in the current set. (NB. The function Refresh Event List can be used to check for new events that have occurred since the last Refresh Event List.)
Read Event Message	(Function Code 3, addresses 40262 – 40314): Contains the current message. Two ASCII characters are packed into each 16 bit register. All unused registers in the set are set to 0.

Appendix E DNP3 Device Profile

Device Properties

This document shows the device capabilities and the current value of each parameter for the default unit configuration as defined in the default configuration file.

1.1 Device Identification	Capabilities	Current Value	If configurable, list methods
1.1.1 Device Function:	○ Master ● Outstation	○ Master ● Outstation	
1.1.2 Vendor Name:		ERLPhase Power Technologies Ltd.	
1.1.3 Device Name:		I/O Expansion	
1.1.4 Device manufacturer's hardware version string:		NA	
1.1.5 Device manufacturer's software version string:		NA	
1.1.6 Device Profile Document Version Number:		V01.0, March 09, 2012	
1.1.7 DNP Levels Supported for:	Masters Only RequestsResponses ☐ ☐ None ☐ ☐ Level 1 ☐ ☐ Level 2 ☐ ☐ Level 3 Outstations Only Requests and Responses ☐ None ☐ Level 1 ☒ Level 2 ☐ Level 3		
1.1.8 Supported Function Blocks:	☐ Self-Address Reservation ☐ Object 0 - attribute objects ☐ Data Sets ☐ File Transfer ☐ Virtual Terminal ☐ Mapping to IEC 61850 Object Models defined in a DNP3 XML file		

1.1 Device Identification	Capabilities	Current Value	If configurable, list methods
1.1.9 Notable Additions:	• Start-stop (qualifier codes 0x00 and 0x01), limited quantity (qualifier codes 0x07 and 0x08) and indices (qualifier codes 0x17 and 0x28) for Binary Inputs, Binary Outputs and Analog Inputs (object groups 1, 10 and 30) • 32-bit and 16-bit Analog Inputs with and without flag (variations 1, 2, 3 and 4) • Analog Input events with time (variations 3 and 4) • Fault Location information as analog readings • Event Log messages as Object groups 110 and 111		
1.1.10 Methods to set Configurable Parameters:	☐ XML - Loaded via DNP3 File Transfer ☐ XML - Loaded via other transport mechanism ☐ Terminal - ASCII Terminal Command Line ☒ Software - Vendor software named TESLA Control Panel ☐ Proprietary file loaded via DNP3 file transfer ☐ Proprietary file loaded via other transport mechanism ☐ Direct - Keypad on device front panel ☐ Factory - Specified when device is ordered ☐ Protocol - Set via DNP3 (e.g. assign class) ☐ Other - explain _____		
1.1.11 DNP3 XML files available On-Line:	RdWrFilenameDescription of Contents ☐ dnpDP.xml Complete Device Profile ☐ dnpDPcap.xml Device Profile Capabilities ☐ dnpDPcfg.xml Device Profile config. values ☐ ☐ _____*.xml _____ *The Complete Device Profile Document contains the capabilities, Current Value, and configurable methods columns. *The Device Profile Capabilities contains only the capabilities and configurable methods columns. *The Device Profile Config. Values contains only the Current Value column.	Not supported	
1.1.12 External DNP3 XML files available Off-line:	Rd WrFilenameDescription of Contents ☐ ☐ dnpDP.xml Complete Device Profile ☐ ☐ dnpDPcap.xml Device Profile Capabilities ☐ ☐ dnpDPcfg.xml Device Profile config. values ☐ ☐ _____*.xml _____ *The Complete Device Profile Document contains the capabilities, Current Value, and configurable methods columns. *The Device Profile Capabilities contains only the capabilities and configurable methods columns. *The Device Profile Config. Values contains only the Current Value column.	Not supported	
1.1.13 Connections Supported:	☒ Serial (complete section 1.2) ☒ IP Networking (complete section 1.3) ☐ Other, explain _____		

1.2 Serial Connections	Capabilities	Current Value	If configurable, list methods
1.2.1 Port Name	SCADA (Port 405)		
1.2.2 Serial Connection Parameters:	☐ Asynchronous - 8 Data Bits, 1 Start Bit, 1 Stop Bit, No Parity ☒ Other, explain - Asynchronous with selectable parity	Not configured for DNP	TESLA Control Panel
1.2.3 Baud Rate:	☐ Fixed at _____ ☐ Configurable, range _____ to _____ ☒ Configurable, selectable from 300, 1200, 2400, 9600, 19200, 38400 and 57600 ☐ Configurable, other, describe_____	Not configured for DNP	TESLA Control Panel
1.2.4 Hardware Flow Control (Handshaking): Describe hardware signaling requirements of the interface. Where a transmitter or receiver is inhibited until a given control signal is asserted, it is considered to require that signal prior to sending or receiving characters. Where a signal is asserted prior to transmitting, that signal will be maintained active until after the end of transmission. Where a signal is asserted to enable reception, any data sent to the device when the signal is not active could be discarded.	☐ None **RS-232 / V.24 / V.28 Options:** Before Tx, Asserts: ☐ RTS ☐ DTR Before Rx, Asserts: ☐ RTS ☐ DTR Always Asserts: ☒ RTS ☒ DTR Before Tx, Requires: Asserted / Deasserted ☐ / ☐ CTS ☐ / ☐ DCD ☐ / ☐ DSR ☐ / ☐ RI ☐ Rx Inactive Before Rx, Requires: Asserted / Deasserted ☐ / ☐ CTS ☐ / ☐ DCD ☐ / ☐ DSR ☐ / ☐ RI Always Ignores: ☒ CTS ☒ DCD ☒ DSR ☒ RI ☐ Other, explain _____ **RS-422 / V.11 Options:** ☐ Requires Indication before Rx ☐ Asserts Control before Tx ☐ Other, explain _____ **RS-485 Options:** ☐ Requires Rx inactive before Tx ☐ Other, explain _____		
1.2.5 Interval to Request Link Status:	☒ Not Supported ☐ Fixed at_____ seconds ☐ Configurable, range _____ to _____ seconds ☐ Configurable, selectable from __,__,__ seconds ☐ Configurable, other, describe_____		
1.2.6 Supports DNP3 Collision Avoidance:	☒ No ☐ Yes, explain _____		

1.2 Serial Connections	Capabilities	Current Value	If configurable, list methods
1.2.7 Receiver Inter-character Timeout:	☒ Not checked ☐ No gap permitted ☐ Fixed at _____ bit times ☐ Fixed at _____ ms ☐ Configurable, range ____ to ____ bit times ☐ Configurable, range ____ to ____ ms ☐ Configurable, Selectable from __,__,__bit times ☐ Configurable, Selectable from ___, ___, ___ ms ☐ Configurable, other, describe_____ ☐ Variable, explain ____		
1.2.8 Inter-character gaps in transmission:	☒ None (always transmits with no inter-character gap) ☐ Maximum _____ bit times ☐ Maximum _____ ms		

1.3 IP Networking	Capabilities	Current Value	If configurable, list methods
1.3.1 Port Name	Port 401 or Port 402		
1.3.2 Type of End Point:	☐ TCP Initiating (Master Only) ☒ TCP Listening (Outstation Only) ☐ TCP Dual (required for Masters) ☒ UDP Datagram (required)	Not configured for DNP	TESLA Control Panel
1.3.3 IP Address of this Device:		192.168.100.101	I/O Expansion Maintenance utilities
1.3.4 Subnet Mask:		Not set	I/O Expansion Maintenance utilities
1.3.5 Gateway IP Address:		Not set	I/O Expansion Maintenance utilities
1.3.6 Accepts TCP Connections or UDP Datagrams from:	☒ Allows all (show as *.*.*.* in 1.3.7) ☒ Limits based on an IP address ☒ Limits based on list of IP addresses ☐ Limits based on a wildcard IP address ☐ Limits based on list of wildcard IP addresses ☐ Other validation, explain_____	Limits based on an IP address	TESLA Control Panel
1.3.7 IP Address(es) from which TCP Connections or UDP Datagrams are accepted:		192.168.1.1	TESLA Control Panel
1.3.8 TCP Listen Port Number:	☐ Not Applicable (Master w/o dual end point) ☐ Fixed at 20,000 ☒ Configurable, range 1025 to 32737 ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	20,000	TESLA Control Panel
1.3.9 TCP Listen Port Number of remote device:	☒ Not Applicable (Outstation w/o dual end point) ☐ Fixed at 20,000 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	NA	
1.3.10 TCP Keep-alive timer:	☐ Fixed at _____ms ☒ Configurable, range 5 to 3,600 s ☐ Configurable, selectable from ___,___,___ms ☐ Configurable, other, describe_____	Disabled	TESLA Control Panel
1.3.11 Local UDP port:	☐ Fixed at 20,000 ☒ Configurable, range 1025 to 32737 ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____ ☐ Let system choose (Master only)	20,000	TESLA Control Panel
1.3.12 Destination UDP port for DNP3 Requests (Master Only):		NA	

1.3 IP Networking	Capabilities	Current Value	If configurable, list methods
1.3.13 Destination UDP port for initial unsolicited null responses (UDP only Outstations):	☒ None ☐ Fixed at 20,000 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	NA	
1.3.14 Destination UDP port for responses:	☐ None ☐ Fixed at 20,000 ☒ Configurable, range 1025 to 32737 ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____ ☐ Use source port number	20,000	TESLA Control Panel
1.3.15 Multiple master connections (Outstations Only):	☒ Supports multiple masters (Outstations only) If supported, the following methods may be used: ☒ Method 1 (based on IP address) - required ☒ Method 2 (based on IP port number) - recommended ☒ Method 3 (browsing for static data) - optional	Method 1 (based on IP address)	TESLA Control Panel
1.3.16 Time synchronization support:	☐ DNP3 LAN procedure (function code 24) ☐ DNP3 Write Time (not recommended over LAN) ☐ Other, explain _____ ☒ Not Supported		

1.4 Link Layer	Capabilities	Current Value	If configurable, list methods
1.4.1 Data Link Address:	☐ Fixed at_____ ☒ Configurable, range 1 to 65519 ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	1	TESLA Control Panel
1.4.2 DNP3 Source Address Validation:	☒ Never ☐ Always, one address allowed (shown in 1.4.3) ☐ Always, any one of multiple addresses allowed ☐ (each selectable as shown in 1.4.3) ☐ Sometimes, explain_____		
1.4.3 DNP3 Source Address(es) expected when Validation is Enabled:	☐ Configurable to any 16 bit DNP Data Link Address value ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	NA	
1.4.4 Self Address Support using address 0xFFFC:	☐ Yes (only allowed if configurable) ☒ No	NA	
1.4.5 Sends Confirmed User Data Frames:	☐ Always ☐ Sometimes, explain _____ ☐ Never ☒ Configurable, either always or never		TESLA Control Panel (to disable, set Data Link Time-out to 0)
1.4.6 Data Link Layer Confirmation Timeout:	☐ None ☐ Fixed at _ ms ☒ Configurable, range __0____ to 2,000 ms ☐ Configurable, selectable from ___,___,___ms ☐ Configurable, other, describe_____ ☐ Variable, explain _____	1,000	
1.4.7 Maximum Data Link Retries:	☐ Never Retries ☒ Fixed at 3 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	3	
1.4.8 Maximum number of octets Transmitted in a Data Link Frame:	☒ Fixed at 292 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	292	
1.4.9 Maximum number of octets that can be Received in a Data Link Frame:	☒ Fixed at 292 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	292	

1.5 Application Layer	Capabilities	Current Value	If configurable, list methods
1.5.1 Maximum number of octets Transmitted in an Application Layer Fragment other than File Transfer:	☒ Fixed at 2048 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	2048	
1.5.2 Maximum number of octets Transmitted in an Application Layer Fragment containing File Transfer:	☐ Fixed at _____ ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	NA	
1.5.3 Maximum number of octets that can be Received in an Application Layer Fragment:	☒ Fixed at 2048 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____	2048	
1.5.4 Timeout waiting for Complete Application Layer Fragment:	☐ None ☒ Fixed at 2,000 ms ☐ Configurable, range _____ to _____ms ☐ Configurable, selectable from ___,___,___ms ☐ Configurable, other, describe_____ ☐ Variable, explain _____	2,000 ms	
1.5.5 Maximum number of objects allowed in a single control request for CROB (group 12):	☒ Fixed at 16 ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____ ☐ Variable, explain _____	16	
1.5.6 Maximum number of objects allowed in a single control request for Analog Outputs (group 41):	☐ Fixed at _ ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____ ☐ Variable, explain _____	Analog Outputs not supported	
1.5.7 Maximum number of objects allowed in a single control request for Data Sets (groups 85,86,87):	☐ Fixed at __ ☐ Configurable, range _____ to _____ ☐ Configurable, selectable from ____,____,____ ☐ Configurable, other, describe_____ ☐ Variable, explain _____	Data Sets not supported	
1.5.8 Supports mixing object groups (AOBs, CROBs and Data Sets) in the same control request:	☐ Not applicable - controls are not supported ☐ Yes ☒ No	Analog Outputs not supported	

1.6 Fill Out The Following Items For Outstations Only	**Capabilities**	**Current Value**	**If configurable, list methods**
1.6.1 Timeout waiting for Application Confirm of solicited response message:	☐ None ☒ Fixed at 5,000 ms ☐ Configurable, range _____ to _____ms ☐ Configurable, selectable from ___,___,___ms ☐ Configurable, other, describe_____ ☐ Variable, explain _____	5,000 ms	
1.6.2 How often is time synchronization required from the master?	☒ Never needs time ☐ Within _____ seconds after IIN1.4 is set ☐ Periodically every _____ seconds		
1.6.3 Device Trouble Bit IIN1.6:	☐ Never used ☒ Reason for setting: Unable to access requested data or execute CROB, assuming a valid request has been received		
1.6.4 File Handle Timeout:	☒ Not applicable, files not supported ☐ Fixed at_____ ms ☐ Configurable, range _____ to _____ms ☐ Configurable, selectable from ___,___,___ms ☐ Configurable, other, describe_____ ☐ Variable, explain _____		
1.6.5 Event Buffer Overflow Behaviour:	☐ Discard the oldest event ☒ Discard the newest event ☐ Other, explain _____		
1.6.6 Event Buffer Organization:	• Single buffer for the Object Groups 2 and 32, size 200. • Separate buffer for the Object Group 111, size 100. • Separate buffer for the Fault Locator events, size 100.		
1.6.7 Sends Multi-Fragment Responses:	☒ Yes ☐ No		
1.6.8 DNP Command Settings preserved through a device reset:	☐ Assign Class ☐ Analog Deadbands ☐ Data Set Prototypes ☐ Data Set Descriptors	Not supported	

1.7 Outstation Unsolicited Response Support	Capabilities	Current Value	If configurable, list methods
1.7.1 Supports Unsolicited Reporting:	☒ Not Supported ☐ Configurable, selectable from On and Off	NA	

1.8 Outstation Performance	Capabilities	Current Value	If configurable, list methods
1.8.1 Maximum Time Base Drift (milliseconds per minute):		NA, not synchronized by DNP	
1.8.2 When does outstation set IIN1.4?	☒ Never ☐ Asserted at startup until first Time Synchronization request received ☐ Periodically, range ____to____ seconds ☐ Periodically, selectable from ____,____,___ seconds ☐ Range ____to____ seconds after last time sync ☐ Selectable from___,___,___seconds after last time sync ☐ When time error may have drifted by range ____to____ ms ☐ When time error may have drifted by selectable from ____,____,___	NA	
1.8.3 Maximum Internal Time Reference Error when set via DNP (ms):		NA	
1.8.4 Maximum Delay Measurement error (ms):		NA	
1.8.5 Maximum Response time (ms):		100 ms (for the case all supported points mapped to the DNP point lists)	TESLA Control Panel
1.8.6 Maximum time from start-up to IIN 1.4 assertion (ms):		NA	
1.8.7 Maximum Event Time-tag error for local Binary and Double-bit I/O (ms):		• 0.1736 ms for 60Hz systems • 0.2083 ms for 50 Hz systems	
1.8.8 Maximum Event Time-tag error for local I/O other than Binary and Double-bit data types (ms):		• 0.1736 ms for 60Hz systems • 0.2083 ms for 50 Hz systems	

Capabilities and Current Settings for Device Database

The following tables identify the capabilities and current settings for each DNP3 data type. Each data type also provides a table defining the data points available in the device or a description of how this information can be obtained if the database is configurable.

2.1 Single-Bit Binary Inputs Static (Steady-State) Group Number: 1 Event Group Number: 2	**Capabilities**	**Current Value**	**If configurable, list methods**
2.1.1 Static Variation reported when variation 0 requested:	☒ Variation 1 - Single-bit Packed format ☐ Variation 2 - Single-bit with flag ☐ Based on point Index (add column to table below)		
2.1.2 Event Variation reported when variation 0 requested:	☐ Variation 1 - without time ☒ Variation 2 - with absolute time ☐ Variation 3 - with relative time ☐ Based on point Index (add column to table below)		
2.1.3 Event reporting mode:	☐ Only most recent ☒ All events		
2.1.4 Binary Inputs included in Class 0 response:	☒ Always ☐ Never ☐ Only if point is assigned to Class 1, 2, or 3 ☐ Based on point Index (add column to table below)		TESLA Control Panel
2.1.5 Definition of Binary Input Point List:	☐ Fixed, list shown in table below ☒ Configurable ☐ Other, explain_____	Complete list is shown in the table below; points excluded from the default configuration are marked with '*'	TESLA Control Panel

NOTES	1. Binary Inputs are scanned with 1 ms resolution. 2. Binary Input data points are user selectable; the data points available in the device for any given Binary Input point selection can be obtained through the TESLA Control Panel software (see SCADA Setting Summary).

Point Index	**Name**	**Default Class Assigned to Events (1, 2, 3 or none)**	**Name for State when value is 0**	**Name for State when value is 1**	**Description**
0	External Input 1	1	Inactive	Active	
1	External Input 2	1	Inactive	Active	
2	External Input 3	1	Inactive	Active	
3	External Input 4	1	Inactive	Active	

Point Index	Name	Default Class Assigned to Events (1, 2, 3 or none)	Name for State when value is 0	Name for State when value is 1	Description
4	External Input 5	1	Inactive	Active	
5	External Input 6	1	Inactive	Active	
6	External Input 7	1	Inactive	Active	
7	External Input 8	1	Inactive	Active	
8	External Input 9	1	Inactive	Active	
9	External Input 10	1	Inactive	Active	
10	External Input 11	1	Inactive	Active	
11	External Input 12	1	Inactive	Active	
12	External Input 13	1	Inactive	Active	
13	External Input 14	1	Inactive	Active	
14	External Input 15	1	Inactive	Active	
15	External Input 16	1	Inactive	Active	
16	External Input17	1	Inactive	Active	
17	External Input 18	1	Inactive	Active	
18	External Input19	1	Inactive	Active	
19	External Input 20	1	Inactive	Active	
20	External Input 21	1	Inactive	Active	
21	External Input 22	1	Inactive	Active	
22	External Input 23	1	Inactive	Active	
23	External Input 24	1	Inactive	Active	
24	External Input 25	1	Inactive	Active	
25	External Input 26	1	Inactive	Active	
26	External Input 27	1	Inactive	Active	
27	External Input 28	1	Inactive	Active	
28	External Input 29	1	Inactive	Active	
29	External Input 30	1	Inactive	Active	
30	External Input 31	1	Inactive	Active	
31	External Input 32	1	Inactive	Active	
32	External Input 32	1	Inactive	Active	
33	External Input 34	1	Inactive	Active	
34	External Input 35	1	Inactive	Active	
35	External Input 36	1	Inactive	Active	
36	External Input 37	1	Inactive	Active	

Point Index	Name	Default Class Assigned to Events (1, 2, 3 or none)	Name for State when value is 0	Name for State when value is 1	Description
37	External Input 38	1	Inactive	Active	
38	External Input 39	1	Inactive	Active	
39	External Input 40	1	Inactive	Active	
40	External Input 41	1	Inactive	Active	
41	External Input 42	1	Inactive	Active	
42	External Input 43	1	Inactive	Active	
43	External Input 44	1	Inactive	Active	
44	External Input 45	1	Inactive	Active	
45	External Input 46	1	Inactive	Active	
46	External Input 47	1	Inactive	Active	
47	External Input 48	1	Inactive	Active	
48	External Input 49	1	Inactive	Active	
49	External Input 50	1	Inactive	Active	
50	External Input 51	1	Inactive	Active	
51	External Input 52	1	Inactive	Active	
52	External Input 53	1	Inactive	Active	
53	External Input 54	1	Inactive	Active	
54	External Input 55	1	Inactive	Active	
55	External Input 56	1	Inactive	Active	
56	External Input 57	1	Inactive	Active	
57	External Input 58	1	Inactive	Active	
58	External Input 59	1	Inactive	Active	
59	External Input 60	1	Inactive	Active	
60	External Input 61	1	Inactive	Active	
61	External Input 62	1	Inactive	Active	
62	External Input 63	1	Inactive	Active	
63	External Input 64	1	Inactive	Active	
64	External Input 65	1	Inactive	Active	
65	External Input 66	1	Inactive	Active	
66	External Input 67	1	Inactive	Active	
67	External Input 68	1	Inactive	Active	
68	External Input 69	1	Inactive	Active	
69	External Input 70	1	Inactive	Active	

Point Index	Name	Default Class Assigned to Events (1, 2, 3 or none)	Name for State when value is 0	Name for State when value is 1	Description
70	External Input 71	1	Inactive	Active	
71	External Input 72	1	Inactive	Active	
72	External Input 73	1	Inactive	Active	
73	External Input 74	1	Inactive	Active	
74	External Input 75	1	Inactive	Active	
75	External Input 76	1	Inactive	Active	
76	External Input 77	1	Inactive	Active	
77	External Input 78	1	Inactive	Active	
78	External Input 79	1	Inactive	Active	
79	External Input 80	1	Inactive	Active	
80	External Input 81	1	Inactive	Active	
81	External Input 82	1	Inactive	Active	
82	External Input 83	1	Inactive	Active	
83	External Input 84	1	Inactive	Active	
84	External Input 85	1	Inactive	Active	
85	External Input 86	1	Inactive	Active	
86	External Input 87	1	Inactive	Active	
87	External Input 88	1	Inactive	Active	
88	External Input 89	1	Inactive	Active	
89	External Input 90	1	Inactive	Active	
90	External Input 91	1	Inactive	Active	
91	External Input 92	1	Inactive	Active	
92	External Input 93	1	Inactive	Active	
93	External Input 94	1	Inactive	Active	
94	External Input 95	1	Inactive	Active	
95	External Input 96	1	Inactive	Active	
96	External Input 97	1	Inactive	Active	
97	External Input 98	1	Inactive	Active	
98	External Input 99	1	Inactive	Active	
99	External Input 100	1	Inactive	Active	
100	External Input 101	1	Inactive	Active	
101	External Input 102	1	Inactive	Active	
102	External Input 103	1	Inactive	Active	

Point Index	Name	Default Class Assigned to Events (1, 2, 3 or none)	Name for State when value is 0	Name for State when value is 1	Description
103	External Input 104	1	Inactive	Active	
104	External Input 105	1	Inactive	Active	
105	External Input 106	1	Inactive	Active	
106	External Input 107	1	Inactive	Active	
107	External Input 108	1	Inactive	Active	
108	External Input 109	1	Inactive	Active	
109	External Input 110	1	Inactive	Active	
110	External Input 111	1	Inactive	Active	
111	External Input 112	1	Inactive	Active	
112	External Input 113	1	Inactive	Active	
113	External Input 114	1	Inactive	Active	
114	External Input 115	1	Inactive	Active	
115	External Input 116	1	Inactive	Active	
116	External Input 117	1	Inactive	Active	
117	External Input 118	1	Inactive	Active	
118	External Input 119	1	Inactive	Active	
119	External Input 120	1	Inactive	Active	
120	External Input 121	1	Inactive	Active	
121	External Input 122	1	Inactive	Active	
122	External Input 123	1	Inactive	Active	
123	External Input 124	1	Inactive	Active	
124	External Input 125	1	Inactive	Active	
125	External Input 126	1	Inactive	Active	
126	External Input 127	1	Inactive	Active	
127	External Input 128	1	Inactive	Active	
128	Output Contact 2	1	Inactive	Active	
129*	Output Contact 3	1	Inactive	Active	
130*	Output Contact 4	1	Inactive	Active	
131*	Output Contact 5	1	Inactive	Active	
132*	Output Contact 6	1	Inactive	Active	
133*	Output Contact 7	1	Inactive	Active	
134*	Output Contact 8	1	Inactive	Active	
135*	Output Contact 9	1	Inactive	Active	

Point Index	Name	Default Class Assigned to Events (1, 2, 3 or none)	Name for State when value is 0	Name for State when value is 1	Description
136*	Output Contact 10	1	Inactive	Active	
137*	Output Contact 11	1	Inactive	Active	
138*	Output Contact 12	1	Inactive	Active	
139*	Output Contact 13	1	Inactive	Active	
140*	Output Contact 14	1	Inactive	Active	
141*	Output Contact 15	1	Inactive	Active	
142*	Output Contact 16	1	Inactive	Active	
143	Time Sync Loss	1	Inactive	Active	

2.2 Binary Output Status And Control Relay Output Block Binary Output Status Group Number: 10 Binary Output Event Group Number: 11 CROB Group Number: 12 Binary Output Command Event Object Num: 13	**Capabilities**	**Current Value**	**If configurable, list methods**
2.2.1 Minimum pulse time allowed with Trip, Close, and Pulse On commands:	☒ Fixed at 0.000 ms (hardware may limit this further) ☐ Based on point Index (add column to table below)		
2.2.2 Maximum pulse time allowed with Trip, Close, and Pulse On commands:	☒ Fixed at 0.000 ms (hardware may limit this further) ☐ Based on point Index (add column to table below)		
2.2.3 Binary Output Status included in Class 0 response:	☒ Always ☐ Never ☐ Only if point is assigned to Class 1, 2, or 3 ☐ Based on point Index (add column to table below)		
2.2.4 Reports Output Command Event Objects:	☒ Never ☐ Only upon a successful Control ☐ Upon all control attempts	Not supported	
2.2.5 Event Variation reported when variation 0 requested:	☐ Variation 1 - without time ☐ Variation 2 - with absolute time ☐ Based on point Index (add column to table below)	Not supported	TESLA Control Panel (See Note 2 below)
2.2.6 Command Event Variation reported when variation 0 requested:	☐ Variation 1 - without time ☐ Variation 2 - with absolute time ☐ Based on point Index (add column to table below)	Not supported	TESLA Control Panel (See Note 2 below)
2.2.7 Event reporting mode:	☐ Only most recent ☐ All events	Not supported	TESLA Control Panel (See Note 2 below)
2.2.8 Command Event reporting mode:	☐ Only most recent ☐ All events	Not supported	
2.2.9 Maximum Time between Select and Operate:	☐ Not Applicable ☒ Fixed at 10 seconds ☐ Configurable, range _____ to _____ seconds ☐ Configurable, selectable from___,___,___seconds ☐ Configurable, other, describe_____ ☐ Variable, explain _____ ☐ Based on point Index (add column to table below)	10 s	
2.2.10 Definition of Binary Output Status/Control relay output block (CROB) Point List:	☐ Fixed, list shown in table below ☒ Configurable ☐ Other, explain_____	Complete list is shown in the table below.	TESLA Control Panel

NOTES

1. Binary Outputs are scanned with 500 ms resolution.

2. Events are not supported for Binary Outputs (group 10), but most of Binary Output points can be mapped to Binary Inputs (group 2) with full Event and Class Data support. See TESLA Control Panel /DNP Configuration/Point Map screen for complete point lists and configuration options.

3. Binary Output data points are user selectable; the data points available in the device for any given Binary Output point selection can be obtained through the TESLA Control Panel software (see SCADA Setting Summary).

Point Index	Name	Supported Control Operations											Name for State when value is 0	Name for State when value is 1	Default Class Assigned to Events (1, 2, 3 or none)		Description
		Select/Operate	Direct Operate	Direct Operate - No Ack	Pulse On / NUL	Pulse Off	Latch On / NUL	Latch Off / NUL	Trip	Close	Count > 1	Cancel Currently Running Operation			Change	Command	
0	Output contact 2	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
1	Output contact 3	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
2	Output contact 4	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
3	Output contact 5	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
4	Output contact 6	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
5	Output contact 7	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
6	Output contact 8	-	-	-	-	-	-	-	-	-	-	-	Inactive	Active	None	None	
7	Output contact 9	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1
8	Output contact 10	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1
9	Output contact 11	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1
10	Output contact 12	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1
11	Output contact 13	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1
12	Output contact 14	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1
13	Output contact 15	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1
14	Output contact 16	Y	Y	Y	Y	-	Y	Y	-	-	-	-	Inactive	Active	None	None	Pulse duration fixed at 1

2.3 Octet String Points Static (Steady-State) Group Number: 110 Event Group Number: 111	**Capabilities**	**Current Value**	**If configurable, list methods**
2.3.1 Event reporting mode *:	☐ Only most recent ☒ All events		
2.3.2 Octet Strings Included in Class 0 response:	☐ Always ☒ Never ☐ Only if point is assigned to Class 1, 2, or 3 ☐ Based on point Index (add column to table below)		
2.3.3 Definition of Octet String Point List:	☐ Fixed, list shown in table below ☐ Configurable (current list may be shown in table below) ☒ Other, explain Used for Event Log access as described below		

* Object 110 and 111 are Octet String Object used to provide access to the Event Log text of the relay. Object 110 always contains the most recent event in the relay. Object 111 is the corresponding change event object.

As stated in the DNP specifications, the variation of the response object represents the length of the string. The string represents the ASCII values of the event text. The first two characters in the string can be used to quickly identify fault location events. Fault locator events begin with the characters "FL" (0x46, 0x4C hex). The following example shows a fault distance event returned through either of the octet string objects:

Event Message:

2000Sep21 20:16:16.966 Output Contact 1 Inactive

DNP Octet string object components:					
0x32	0x30	0x30	0x30	0x53	0x65
0x70	0x32	0x31	0x20	0x32	0x30
0x3A	0x31	0x36	0x3A	0x31	0x36
0x2E	0x39	0x36	0x36	0x20	0x4F
0x75	0x74	0x70	0x75	0x74	0x20
0x43	0x6F	0x6E	0x74	0x61	0x63
0x74	0x20	0x31	0x20	0x4F	0x70
0x65	0x6E	0x65	0x64		

Implementation Table

The following implementation table identifies which object groups and variations, function codes and qualifiers the device supports in both requests and responses. The Request columns identify all requests that are parsed by an Outstation. The Response columns identify all responses that may be sent by an Outstation.

NOTES

The implementation table lists all functionality required by the device (Outstation) as defined within the DNP3 IED Conformance Test Procedures. Any functionality beyond the highest subset level supported is indicated by highlighted rows. Any Object Groups not provided by an outstation are indicated by strikethrough (note these Object Groups will still be parsed).

DNP Object Group & Variation			Request Outstation parses		Response Outstation can issue	
Group Num	**Var Num**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
1	0	Binary Input - Any Variation	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
1	1	Binary Input - Packed format	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
1	2	Binary Input - With flags	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
2	0	Binary Input Event - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
2	1	Binary Input Event - Without time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) ~~130 (unsol. resp)~~	17, 28 (index)
2	2	Binary Input Event - With absolute time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) ~~130 (unsol. resp)~~	17, 28 (index)
2	3	Binary Input Event - With relative time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) ~~130 (unsol. resp)~~	17, 28 (index)
10	0	Binary Output - Any Variation	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
10	2	Binary Output - Output Status with flag	1 (read)	06 (no range, or all) 00, 01 (start-stop) 07, 08 (limited qty) 17, 28 (index)	129 (response)	00, 01 (start-stop)
12	1	Binary Command - Control relay output block (CROB)	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, no ack)	17, 28 (index)	129 (response)	Echo of request
20	0	~~Counter - Any Variation~~	1 (read) 7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack)	06 (no range, or all)	129 (response)	

DNP Object Group & Variation			Request Outstation parses		Response Outstation can issue	
Group Num	**Var Num**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
20	1	~~Counter - 32-bit with flag~~			**129** (response)	~~**00, 01** (start-stop)~~
20	2	~~Counter - 16-bit with flag~~			**129** (response)	~~**00, 01** (start-stop)~~
20	5	~~Counter - 32-bit without flag~~			**129** (response)	~~**00, 01** (start-stop)~~
20	6	~~Counter - 16-bit without flag~~			**129** (response)	~~**00, 01** (start-stop)~~
21	0	~~Frozen Counter - Any Variation~~	**1** (read)	**06** (no range, or all)		
21	1	~~Frozen Counter - 32-bit with flag~~			**129** (response)	~~**00, 01** (start-stop)~~
21	2	~~Frozen Counter - 16-bit with flag~~			**129** (response)	~~**00, 01** (start-stop)~~
21	9	~~Frozen Counter - 32-bit without flag~~			**129** (response)	~~**00, 01** (start-stop)~~
21	10	~~Frozen Counter - 16-bit without flag~~			**129** (response)	~~**00, 01** (start-stop)~~
22	0	~~Counter Event - Any Variation~~	**1** (read)	**06** (no range, or all) **07, 08** (limited qty)	**129** (response)	
22	1	~~Counter Event - 32-bit with flag~~			**129** (response) ~~**130** (unsol. resp)~~	~~**17, 28** (index)~~
22	2	~~Counter Event - 16-bit with flag~~			**129** (response) ~~**130** (unsol. resp)~~	~~**17, 28** (index)~~
30	0	~~Analog Input - Any Variation~~	**1** (read)	**06** (no range, or all) **00, 01** (start-stop) **07, 08** (limited qty) **17, 28** (index)	**129** (response)	~~**00, 01** (start-stop)~~
30	1	~~Analog Input - 32-bit with flag~~	**1** (read)	**06** (no range, or all) **00, 01** (start-stop) **07, 08** (limited qty) **17, 28** (index)	**129** (response)	~~**00, 01** (start-stop)~~
30	2	~~Analog Input - 16-bit with flag~~	**1** (read)	**06** (no range, or all) **00, 01** (start-stop) **07, 08** (limited qty) **17, 28** (index)	**129** (response)	~~**00, 01** (start-stop)~~
30	3	~~Analog Input - 32-bit without flag~~	**1** (read)	**06** (no range, or all) **00, 01** (start-stop) **07, 08** (limited qty) **17, 28** (index)	**129** (response)	~~**00, 01** (start-stop)~~
30	4	~~Analog Input - 16-bit without flag~~	**1** (read)	**06** (no range, or all) **00, 01** (start-stop) **07, 08** (limited qty) **17, 28** (index)	**129** (response)	~~**00, 01** (start-stop)~~
32	0	~~Analog Input Event - Any Variation~~	**1** (read)	**06** (no range, or all) **07, 08** (limited qty)	**129** (response)	~~**17, 28** (index)~~
32	1	~~Analog Input Event - 32-bit without time~~	**1** (read)	**06** (no range, or all) **07, 08** (limited qty)	**129** (response) **130** ~~(unsol. resp)~~	~~**17, 28** (index)~~
32	2	~~Analog Input Event - 16-bit without time~~	**1** (read)	**06** (no range, or all) **07, 08** (limited qty)	**129** (response) **130** ~~(unsol. resp)~~	~~**17, 28** (index)~~
32	3	~~Analog Input Event - 32-bit with time~~	1 (read)	**06** (no range, or all) **07, 08** (limited qty)	129 (response)	~~**17, 28** (index)~~
32	4	~~Analog Input Event - 16-bit with time~~	1 (read)	**06** (no range, or all) **07, 08** (limited qty)	129 (response)	~~**17, 28** (index)~~
40	0	~~Analog Output Status - Any Variation~~	**1** (read)	**06** (no range, or all)	**129** (response)	
40	2	~~Analog Outpu Status - 16-bit with flag~~			129 (response)	~~**00, 01** (start-stop)~~

DNP Object Group & Variation			Request Outstation parses		Response Outstation can issue	
Group Num	**Var Num**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
41	2	~~Analog Output - 16-bit~~	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, no ack)	17, 28 (index)	129 (response)	~~Echo of request~~
50	1	~~Time and Date - Absolute time~~	2 (write)	07 (limited qty = 1)	129 (response)	
51	1	~~Time and Date CTO - Absolute time, synchronized~~			~~129 (response)~~ ~~130 (unsol. resp)~~	~~07 (limited qty) (qty = 1)~~
51	2	Time and Date CTO - Absolute time, unsynchronized			129 (response) ~~130 (unsol. resp)~~	07 (limited qty) (qty = 1)
52	1	Time Delay - Coarse			129 (response)	07 (limited qty) (qty = 1)
52	2	~~Time delay - Fine~~			~~129 (response)~~	~~07 (limited qty) (qty = 1)~~
60	1	Class Objects - Class 0 data	1 (read)	06 (no range, or all)	129 (response)	00, 01 (start-stop)
60	2	Class Objects - Class 1 data	1 (read)	06 (no range, or all)	129 (response)	17, 28 (index)
60	3	Class Objects - Class 2 data	1 (read)	06 (no range, or all)	129 (response)	17, 28 (index)
60	4	Class Objects - Class 3 data	1 (read)	06 (no range, or all)	129 (response)	17, 28 (index)
80	1	Internal Indications - Packet format	2 (write)	00 (start-stop) (index = 7)	129 (response)	
110	0	Octet string	1 (read)	06 (no range, or all)	129 (response)	07 (limited qty)
111	0	Octet string event	1 (read)	06 (no range, or all)	129 (response)	07 (limited qty)
No Object (function code only)			13 (cold restart)		129 (response)	
No Object (function code only)			14 (warm restart)		129 (response)	
No Object (function code only)			23 (delay meas.)		129 (response)	

Appendix F Recommended Spare Parts List

Table F.1: ERL I/O Expansion Recommended Spare Parts List		
Part Number	**Part Description**	**Quantity**
113724 or 113726	ERL I/O Expansion Unit - 128 Digital Channels, 16 Output Contacts or B-PRO I/O Expansion Unit - 128 Digital Channels, 16 Output Contacts	*
101850	Digital Input Shorting Bar, 8 inputs	*
106791	Users Manual in Binder	*
101787	DB9F Serial (Personal Computer) to DB9M (TESLA) Cable	*
102404	RS232 to RS485 Converter, Optically Isolated, DIN Rail Mounting	*
107051	RS232 Serial to Parallel Port Converter	*

Note: * = One of each component used

Appendix G ERL I/O Expansion Handling and Disposition

Unpacking

- To unpack an ERL I/O Expansion System Unit
- Open the bottom of the box.
- Place the box on the floor or a secure table.
- Lift the box off of the unit leaving the ERL I/O Expansion and packing material standing intact.
- Remove the packing material from the ERL I/O Expansion.
- Dispose of the packing materials and box in a manner consistent with local waste disposal procedures and regulations. We recommend recycling the box.

Long Term Storage

For long term storage:

- Store the ERL I/O Expansion system unit in original packing container.
- Protect any of the components not in original packing from dust accumulation and moisture.
- Store all components indoors and protect from moisture accumulation.

Final Disposition

Regulations governing disposal of electronics are rapidly being adopted and are constantly changing. We recommend that local electronics disposal regulations be reviewed prior to disposal of an ERL I/O Expansion system when it has reached the end of its useful life. The ERL I/O Expansion system unit contains a battery that should be disposed of separately and may contain other electronic components that are potentially subject to specific disposal instructions. Use a local electronics recycler who is familiar with local regulations.

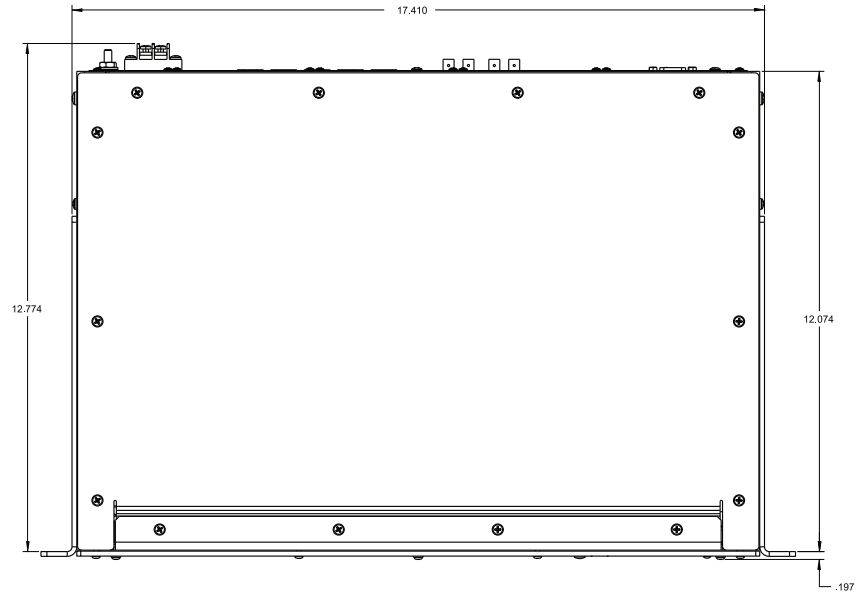
Appendix H ERL I/O Expansion Drawings

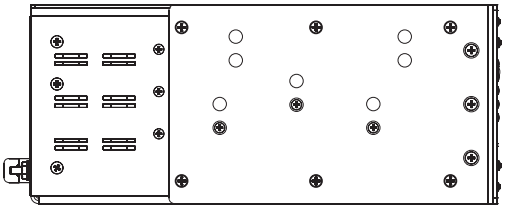
This appendix contains mechanical and connection drawings for the ERL I/O Expansion Unit.

ERL I/O Expansion Mechanical Overview

ERL I/O Expansion Rear Panel View

Electronic versions of the drawings in both PDF and DWG formats are available on the ERL I/O Expansion CD in the Manuals directory. The PDF documents are scaled for 11" x 17" printing for improved readability.





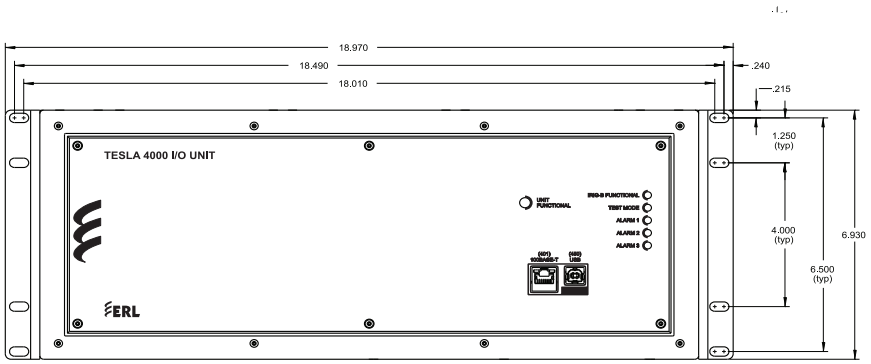


Figure G.1: Mechanical Drawings

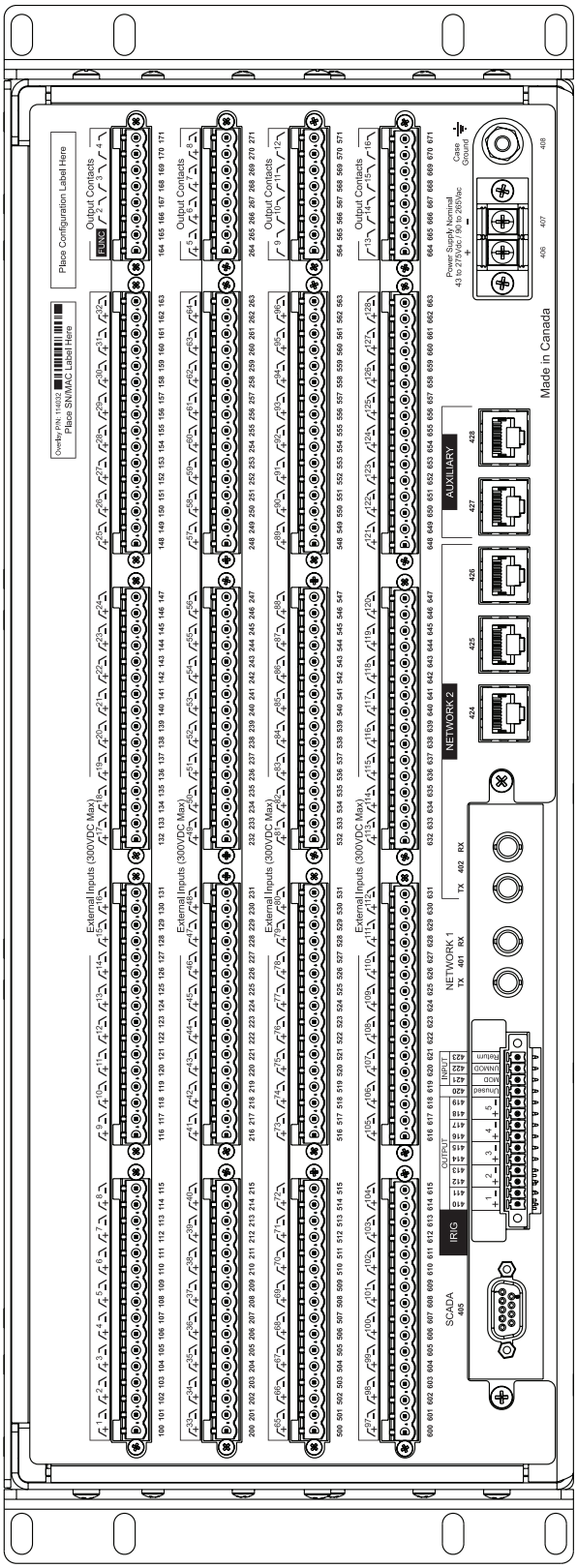


Figure G.2: Back View

Appendix I IEC 61850 Implementation for I/O Expansion Unit

I.1 Protocol Implementation Conformance Statement (PICS) for I/O Expansion Unit

Introduction

This specification is the Protocol Implementation Conformance Statement (PICS) and presents the ACSI conformance statements as defined in Annex A of Part 7-2 of the IEC 61850 standard specifications.

ACSI Basic Conformance Statement

The basic conformance statement shall be as defined in Table I.1: ACSI Basic Conformance Statement.

Table I.1: ACSI Basic Conformance Statement

		Server/ Publishe	Remarks
Client -Server Roles			
B11	Server Side (of TWO-PARTY-APPLICATION-ASSOCIATION)	c1	YES
B12	Client Side (of TWO-PARTY- APPLICATION-ASSOCIATION)		NO
SCSMs supported			
B21	SCSM:IEC 61850-8-1 used		YES
B22	SCSM:IEC 61850-9-1 used		NO
B23	SCSM:IEC 61850-9-2 used		NO
B24	SCSM: other		NO
Generic Substation event Model(GSE)			
B31	Publisher side	O	YES
B32	Subscriber Side		YES
Transmission of Sampled value model (SVC)			
B41	Publisher side	O	NO
B42	Subscriber side	-	NO
c1 - Shall be 'M' if support for LOGICAL-DEVICE model has been declared			

ACSI Models Conformance Statement

The ASCI models conformance statement shall be as defined in Table I.2: ACSI models Conformance Statement.

Table I.2: ACSI models Conformance Statement

		Server/ Publishe	Remarks
If Server side (B11) supported			
M1	Logical Device	c2	YES
M2	Logical Node	c3	YES
M3	Data	c4	YES
M4	Data Set	c5	YES
M5	Substitution	O	NO
M6	Setting group control	O	NO
Reporting			
M7	Buffered report control	O	YES
M7-1	Sequence – number		YES
M7-2	Report-time-stamp		YES
M7-3	Reason-for-inclusion		YES
M7-4	Data-set-name		YES
M7-5	Data-reference		YES
M7-6	Buffer-overflow		YES
M7-7	Entry id		YES
M7-8	Buf Tm		YES
M7-9	IntgPd		YES
M7-10	GI		YES
M8	Unbuffered report control	O	NO
M8-1	Sequence – number		NO
M8-2	Report-time-stamp		NO
M8-3	Reason-for-inclusion		NO
M8-4	Data-set-name		NO
M8-5	Data-reference		NO
M8-6	IntgPd		NO
M8-7	GI		NO
	Logging	O	NO

Table I.2: ACSI models Conformance Statement			
M9	Log control	O	NO
M9-1	IntgPd		NO
M10	Log	O	NO
M11	Control	M	YES
If **GSE** (B31/B32) is supported			
	GOOSE	O	YES
M12-1	EntryID		
M12-2	DataReflnc		
M13	GSSE	O	NO
If **SVC** (B41/B42) is supported			
M14	Multicast SVC	O	NO
M15	Unicast SVC	O	NO
M16	Time	M	YES
M17	File Transfer	O	NO
c2 – shall be 'M' if support for LOGICAL-NODE model has been declared c3 – shall be 'M' if support for DATA model has been declared c4 – shall be 'M' if support DATA-SET, Substitution, Report, Log Control, or Time model has been declared c5 – shall be 'M' if support for Report , GSE, or SV model has been declared M - Mandatory			

ACSI Service Conformance Statement

The ASCI service conformance statement shall be as defined in Table I.3: ACSI Service Conformance Statement.

Table I.3: ACSI Service Conformance Statement				
	Services	**AA: TP/ MC**	**Server/ Publisher**	**Remarks**
Server (Clause 6)				
S1	ServerDirectory	TP	M	YES
Application Association (Clause 7)				
S2	Associate		M	YES
S3	Abort		M	YES
S4	Release		M	YES

Table I.3: ACSI Service Conformance Statement

Logical Device (Clause 8)				
S5	Logical Device Directory	TP	M	YES
Logical Node (Clause 9)				
S6	LogicalNodeDirectory	TP	M	YES
S7	GetAllDataValues	TP	M	YES
Data (Clause 10)				
S8	GetDataValues	TP	M	YES
S9	SetDataValues	TP	O	NO
S10	GetDataDirectory	TP	M	YES
S11	GetDataDefinition	TP	M	YES
Data Set (Clause 11)				
S12	GetDataSetValues	TP	M	YES
S13	SetDataSetValues	TP	M	NO
S14	CreateDataSet	TP	M	NO
S15	DeleteDataSet	TP	M	NO
S16	GetDataSetDirectory	TP	M	YES
Substitution (Clause 12)				
S17	SetDataValues	TP	M	NO
Setting Group Control (Clause 13)				
S18	SelectActive SG	TP	O	NO
S19	SelectEdit SG	TP	O	NO
S20	SetSGvalues	TP	O	NO
S21	ConfirmEditSGvalues	TP	O	NO
S22	GetSGvalues	TP	O	NO
S23	GetSGCBvalues	TP	O	NO
Reporting (Clause 14)				
Buffered Report Control Block (BRCB)				
S24	Report	TP	c6	YES
S24-1	Data-change(dchg)			YES
S24-2	qchg-change(qchg)			NO
S24-3	Data-update(dupd)			NO
S25	GetBRCBValues	TP	c6	YES
S26	SetBRCBValues	TP	c6	YES
Unbuffered report control block(URCB)				

Table I.3: ACSI Service Conformance Statement

S27	Report	TP	c6	YES
S27-1	Data-change(dchg)			YES
S27-2	qchg-change(qchg)			NO
S27-3	Data-update(dupd)			NO
S28	GetURCBValues	TP	c6	YES
S29	SetURCBValues	TP	c6	YES
c6 - shall declare support for at least one (BRCB or URCB)				
Logging (clause 14)				
Log Control Block				
S30	GetLCBValues	TP	M	NO
S31	SetLCBValues	TP	M	NO
Log				
S32	QueryLogByTime	TP	M	NO
S33	QueryLogAfter	TP	M	NO
S34	GetLogStatusValues	TP	v	NO
c7- shall declare support for at least one(query log by time or Query LogAfter)				
Generic Substation event model (GSE) (14.3.5.3.4)				
GOOSE - CONTROL - BLOCK				
S35	SendGOOSEMessage	MC	c8	YES
S36	GetGOReference	TP	c9	NO
S37	GetGOOSEElementNumber	TP	c9	NO
S38	GetGoCBValues	TP	O	YES
S39	SetGoCBValues	TP	O	YES
GSSE - CONTROL - BLOCK				
S40	SendGSSEMessage	MC	C8	NO
S41	GetGsReference	TP	C9	NO
S42	GetGSSEElementNumber	TP	C9	NO
S43	GetGsCBValues	TP	O	NO
S44	SetGsCBValues	TP	O	NO
c8- shall declare support for at least one(Send GOOSE Message or Send GSSE Message) c9- shall declare support if TP association is available				
Transmission of sAmpled Value Model (SVC) (Clause 16)				
S45	SendMSVMessage	MC	C10	NO
S46	GetMSVCBValues	TP	O	NO
S47	SetMSVCBValues	TP	O	NO

Table I.3: ACSI Service Conformance Statement

Unicast SVC				
S48	SendUSVMessage	TP	C10	NO
S49	GetUSVCBValues	TP	O	NO
S50	SetUSVCBValues	TP	O	NO
C10- shall declare support for at least one(Send MSV Message or Send USV Message)				
Control (17.5.1)				
S51	Select	TP	O	NO
S52	Select with value	TP	O	NO
S53	Cancel	TP	O	NO
S54	Operate	TP	M	NO
S55	Command-Termination	TP	O	NO
S56	Time Activated-Operate	TP	O	NO
File Transfer (Clause 20)				
S57	GetFile	TP	M	YES
S58	SetFile	TP	O	YES
S59	DeleteFile	TP	O	YES
S60	GetFileAttributeValues	TP	M	YES
Time (5.5)				
T1	Time resolution of Internal clock	10 (1 ms)		Nearest negative power of 2 in seconds
T2	Time Accuracy of Internal clock			T0
				T1
				T2
				T3
				T4
				T5
T3	Supported Time Stamp resolution	10 (1 ms)		Nearest value of 2**-n in seconds according to 5.5.3.7.3.3

I.2 Model Implementation Conformance Statement (MICS)

Introduction

This specification is the Model Implementation Conformance Statement (MICS) and presents the top-level IEC 61850 data model that has been implemented. The definitions of all used Logical Nodes and their associated Common Data Classes, components and associated enumerated values are also included for completeness.

The reader is expected to be conversant with the terminology presented within the IEC 61850 part 7 series of specifications.

Objective

To provide comprehensive details of the standard data object model elements supported by the device. The MICS is conformant to the devices associated ICD (Substation Configuration Language) file, according to part 6 of the IEC 61850 standards. The layout of the presented tables within this document is conformant to the part 7 series of the IEC 61850 standard specifications with the following exceptions:

- The “Trigger Options” field is not presented
- The “M/O” field is not present as the definitions are as deployed within the model
- An additional column “X” is used to signify custom attributes

Logical Device Definitions

This IEC 61850 server device contains one Logical Device. Logical Device contains a data model built from instances of specific Logical Nodes and must consist of at least an instance of the LPHD Logical Node (which is responsible for providing physical device information) and an instance of the LLN0 Logical Node (for addressing common issues across the Logical Device). The IEC 61850 data model is contained within the Logical Devices detailed in the table below. All LNs are categorized according to the following table to ensure that data model variables in them have respective scope of data information.

Logical Device	Comment / Usage
Triggers	Trigger Status Domain
Output	Outputs Domain
Records	Records Domain
ExtRcdTriggers	External Record Trigger

IEC 61850 Logical Device Data Model

The IEC 61850 Logical Device top-level data model consists of instances of Logical Nodes. The data model name for a Logical Node instance is constructed from an optional prefix (known as the wrapper), the Logical Node name, and an instance ID (or suffix).

Logical Device: Triggers

Sl No	LN Instance	LN Type	Description
1	LLN0	LLN0	Logical node zero
2	LPHD1	LPHD1	Physical device information
3	DIGRBDR1	RBDR1	Disturbance Recorder Channel Binary
4	DIGRBDR2	RBDR1	
5	DIGRBDR3	RBDR1	
6	DIGRBDR4	RBDR1	
7	DIGRBDR5	RBDR1	
8	DIGRBDR6	RBDR1	
9	DIGRBDR7	RBDR1	
10	DIGRBDR8	RBDR1	
11	DIGRBDR9	RBDR1	
12	DIGRBDR10	RBDR1	
13	DIGRBDR11	RBDR1	
14	DIGRBDR12	RBDR1	
15	DIGRBDR13	RBDR1	
16	DIGRBDR14	RBDR1	
17	DIGRBDR15	RBDR1	
18	DIGRBDR16	RBDR1	
19	DIGRBDR17	RBDR1	
20	DIGRBDR18	RBDR1	
21	DIGRBDR19	RBDR1	
22	DIGRBDR20	RBDR1	
23	DIGRBDR21	RBDR1	
24	DIGRBDR22	RBDR1	
25	DIGRBDR23	RBDR1	
26	DIGRBDR24	RBDR1	
27	DIGRBDR25	RBDR1	
28	DIGRBDR26	RBDR1	

29	DIGRBDR27	RBDR1	
30	DIGRBDR28	RBDR1	
31	DIGRBDR29	RBDR1	
32	DIGRBDR30	RBDR1	
33	DIGRBDR31	RBDR1	
34	DIGRBDR32	RBDR1	
35	DIGRBDR33	RBDR1	
36	DIGRBDR34	RBDR1	
37	DIGRBDR35	RBDR1	
38	DIGRBDR36	RBDR1	
39	DIGRBDR37	RBDR1	
40	DIGRBDR38	RBDR1	
41	DIGRBDR39	RBDR1	
42	DIGRBDR40	RBDR1	
43	DIGRBDR41	RBDR1	
44	DIGRBDR42	RBDR1	
45	DIGRBDR43	RBDR1	
46	DIGRBDR44	RBDR1	
47	DIGRBDR45	RBDR1	
48	DIGRBDR46	RBDR1	
49	DIGRBDR47	RBDR1	
50	DIGRBDR48	RBDR1	
51	DIGRBDR49	RBDR1	
52	DIGRBDR50	RBDR1	
53	DIGRBDR51	RBDR1	
54	DIGRBDR52	RBDR1	
55	DIGRBDR53	RBDR1	
56	DIGRBDR54	RBDR1	
57	DIGRBDR55	RBDR1	
58	DIGRBDR56	RBDR1	
59	DIGRBDR57	RBDR1	
60	DIGRBDR58	RBDR1	
61	DIGRBDR59	RBDR1	
62	DIGRBDR60	RBDR1	
63	DIGRBDR61	RBDR1	
64	DIGRBDR62	RBDR1	

65	DIGRBDR63	RBDR1	
66	DIGRBDR64	RBDR1	
67	DIGRBDR65	RBDR1	
68	DIGRBDR66	RBDR1	
69	DIGRBDR67	RBDR1	
70	DIGRBDR68	RBDR1	
71	DIGRBDR69	RBDR1	
72	DIGRBDR70	RBDR1	
73	DIGRBDR71	RBDR1	
74	DIGRBDR72	RBDR1	
75	DIGRBDR73	RBDR1	
76	DIGRBDR74	RBDR1	
77	DIGRBDR75	RBDR1	
78	DIGRBDR76	RBDR1	
79	DIGRBDR77	RBDR1	
80	DIGRBDR78	RBDR1	
81	DIGRBDR79	RBDR1	
82	DIGRBDR80	RBDR1	
83	DIGRBDR81	RBDR1	
84	DIGRBDR82	RBDR1	
85	DIGRBDR83	RBDR1	
86	DIGRBDR84	RBDR1	
87	DIGRBDR85	RBDR1	
88	DIGRBDR86	RBDR1	
89	DIGRBDR87	RBDR1	
90	DIGRBDR88	RBDR1	
91	DIGRBDR89	RBDR1	
92	DIGRBDR90	RBDR1	
93	DIGRBDR91	RBDR1	
94	DIGRBDR92	RBDR1	
95	DIGRBDR93	RBDR1	
96	DIGRBDR94	RBDR1	
97	DIGRBDR95	RBDR1	
98	DIGRBDR96	RBDR1	
99	DIGRBDR97	RBDR1	
100	DIGRBDR98	RBDR1	

101	DIGRBDR99	RBDR1	
102	DIGRBDR100	RBDR1	
103	DIGRBDR101	RBDR1	
104	DIGRBDR102	RBDR1	
105	DIGRBDR103	RBDR1	
106	DIGRBDR104	RBDR1	
107	DIGRBDR105	RBDR1	
108	DIGRBDR106	RBDR1	
109	DIGRBDR107	RBDR1	
110	DIGRBDR108	RBDR1	
111	DIGRBDR109	RBDR1	
112	DIGRBDR110	RBDR1	
113	DIGRBDR111	RBDR1	
114	DIGRBDR112	RBDR1	
115	DIGRBDR113	RBDR1	
116	DIGRBDR114	RBDR1	
117	DIGRBDR115	RBDR1	
118	DIGRBDR116	RBDR1	
119	DIGRBDR117	RBDR1	
120	DIGRBDR118	RBDR1	
121	DIGRBDR119	RBDR1	
122	DIGRBDR120	RBDR1	
123	DIGRBDR121	RBDR1	
124	DIGRBDR122	RBDR1	
125	DIGRBDR123	RBDR1	
126	DIGRBDR124	RBDR1	
127	DIGRBDR125	RBDR1	
128	DIGRBDR126	RBDR1	
129	DIGRBDR127	RBDR1	
130	DIGRBDR128	RBDR1	

Logical Device: Records

Sl No	LN Instance	LN Type	Description
1	LLN0	LLN0	Logical node zero
2	LPHD1	LPHD1	Physical device information
3	RDRE1	RDRE1	Disturbance recorder function

Logical Device: Output

Sl No	LN Instance	LN Type	Description
1	LLN0	LLN0	Logical node zero
2	LPHD1	LPHD1	Physical device information
3	SUBSCRGGIO1	GGIO_16	Output Contacts

Logical Device : ExtRcdTriggers

Sl No	LN Instance	LN Type	Description
1	LLN0	LLN0	Logical node zero
2	LPHD1	LPHD1	Physical device information
3	SUBSCRGGIO1	GGIO1	External Record Triggers

Logical Node Definitions

The definition tables for each of the Logical Nodes in the top-level data model are presented in the following sub-sections.

The following table presents a summary of the Logical Node templates used across the Logical Devices within the overall IEC 61850-product data model:

LN Type	LN Class	Name Space
LLN0	LLN0	IEC61850–7–4: 2003
LPHD1	LPHD	IEC61850–7–4: 2003
RBDR1	RBDR	IEC61850–7–4: 2003
RDRE1	RDRE	IEC61850–7–4: 2003
GGIO1	GGIO	IEC61850–7–4: 2003
GGIO_16	GGIO	IEC61850–7–4: 2003

Logical Node Type: LPHD1

Description: Physical Device Information

LN Class: LPHD

Attribute	Attr. Type	Explanation	T	X
PhyNam	DPL_1_PhyNam	Device Physical Name Plate		
PhyHealth	INS_1_Health	Physical Device Health		
Proxy	SPS_1_Proxy	Indicates if this device is proxy		

Logical Node Type: LLN0

Description: Logical Node 0

LN Class: LLN0

Attribute	Attr. Type	Explanation	T	X
Mod	INC_1_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_1_NamPlt	Name Plate		

Logical Node Type: RBDR1

Description: R

LN Class: RBDR

Attribute	Attr. Type	Explanation	T	X
Mod	INC_1_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_2_NamPlt	Name Plate		
ChTrg	SPS_1_Proxy			

Logical Node Type: GGIO1

Description:

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_1_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_2_NamPlt	Name Plate		
Ind1-Ind128	SPS_1_Proxy			

Logical Node Type: GGIO_16

Description:

LN Class: GGIO

Attribute	Attr. Type	Explanation	T	X
Mod	INC_1_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_1_NamPlt	Name Plate		
Ind1-Ind16	SPS_1_Proxy			

Logical Node Type: RDRE1

Description: Disturbance Recorder function

LN Class: RDRE

Attribute	Attr. Type	Explanation	T	X
Mod	INC_1_Mod	Mode		
Beh	INS_1_Beh	Behaviour		
Health	INS_1_Health	Health		
NamPlt	LPL_2_NamPlt	Name Plate		
RcdTrg	SPC_1_RcdTrg			
RcdMade	SPS_1_Proxy			
FltNum	INS_1_FltNum			
RcdStr	SPS_1_Proxy			
MemUsed	INS_1_FltNum			

Common Data Class Definitions

The definition tables for each of the Common Data Classes used in the Logical Node definitions are presented in the following sub-sections.

From an application point-of-view the data attributes of a Common Data Class are classified according to their specific use. The characterization of data attributes, and the services that they support/provide, will be through the use of 'Functional Constraints'. The Functional Constraints are specified by the table below:

FC Name	Semantic	Source Definition
BR	Buffered Reports	IEC 61850 – 7 - 2
CF	Configuration	IEC 61850 – 7 - 2
CO	Control	IEC 61850 – 7 - 2
DC	Description	IEC 61850 – 7 - 2
EX	Extended Definition	IEC 61850 – 7 - 2
GO	GOOSE Control	IEC 61850 – 7 - 2
GS	GSSE Control (UCA2GOOSE)	IEC 61850 – 7 - 2
LG	Logging	IEC 61850 – 7 - 2
MS	Multicast Sampled Value Control	IEC 61850 – 7 - 2
RP	Unbuffered Reports	IEC 61850 – 7 - 2
SE	Setting Group Editable	IEC 61850 – 7 - 2
SG	Setting Group	IEC 61850 – 7 - 2
SP	Set Point	IEC 61850 – 7 - 2
ST	Status information	IEC 61850 – 7 - 2
SV	Substitution Values	IEC 61850 – 7 - 2
US	Unicast Sampled Value Control	IEC 61850 – 7 - 2
XX	Data Attribute Service Parameters	IEC 61850 – 7 - 2

Common Data Class: DPL_1_PhyNam

Description: Standard Device Name Plate

CDC Class: DPL

Attribute	Type	FC	Enumeration	Comment	X
Vendor	VisString255	DC			
hwRev	VisString255	DC			
swRev	VisString255	DC			
serNum	VisString255	DC			
Model	VisString255	DC			

Common Data Class: INC_1_Mod

Description:

CDC Class: INC

Attribute	Type	FC	Enumeration	Comment	X
stVal	Enum	ST	Mod		
q	Quality	ST			
t	Timestamp	ST			
ctlModel	Enum	CF	ctlModel		

Common Data Class: INS_1_Beh

Description:

CDC Class: INS

Attribute	Type	FC	Enumeration	Comment	X
stVal	Enum	ST	Beh		
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: INS_1_Health

Description:

CDC Class: INS

Attribute	Type	FC	Enumeration	Comment	X
stVal	Enum	ST	Health		
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: LPL_1_NamPlt

Description:

CDC Class: LPL

Attribute	Type	FC	Enumeration	Comment	X
Vendor	VisString255	DC			
swRev	VisString255	DC			
d	VisString255	DC			
configRev	VisString255	DC			
ldNs	VisString255	EX			

Common Data Class: LPL_2_NamPlt

Description:

CDC Class: LPL

Attribute	Type	FC	Enumeration	Comment	X
Vendor	VisString255	DC			
swRev	VisString255	DC			
d	VisString255	DC			

Common Data Class: SPS_1_Proxy

Description:

CDC Class: SPS

Attribute	Type	FC	Enumeration	Comment	X
stVal	BOOLEAN	ST			
q	Quality	ST			
t	Timestamp	ST			

Common Data Class: SPC_1_RcdTrg

Description:

CDC Class: SPC

Attribute	Type	FC	Enumeration	Comment	X
stVal	BOOLEAN	ST			
q	Quality	ST			
t	Timestamp	ST			
ctlModel	Enum	CF	ctlModel		

Common Data Class: SPC_1_FltNum

Description:

CDC Class: INS

Attribute	Type	FC	Enumeration	Comment	X
stVal	INT32	ST			
q	Quality	ST			
t	Timestamp	ST			

Enumerated Type Definitions

The following sub-sections specify the enumerations that are associated to some Common Data

Class attributes. The definition of the enumerations is according to IEC 61850-7-3 and IEC

61850-7-4 unless otherwise stated.

Enumerated type: Beh

Description: Behaviour

Ordinal	Semantic
1	on
2	blocked
3	test
4	test/blocked
5	off

Enumerated type: Health

Description: Behaviour

Ordinal	Semantic
1	Ok
2	Warning
3	Alarm

Enumerated type: Mod

Description: Mode

Ordinal	Semantic
1	on
2	blocked
3	test
4	test/blocked
5	off

Enumerated type: ctlMod

Description: Mode

Ordinal	Semantic
0	status-only
1	direct-with-normal-security
2	sbo-with-normal-security
3	direct-with-enhanced-security
4	sbo-with-enhanced-security

I.3 Data Mapping Specifications

I/O Expansion Logical Devices

I/O Expansion Logical Device identification

The I/O Expansion has the following IEC 61850 Logical Devices defined in its ICD file:

- ExtRcdTriggers
- Output
- Records
- Triggers

I/O Expansion Logical Nodes

The following table defines the list of logical nodes (LN) for the I/O Expansion Logical Devices.

Note: System logical nodes (group L) are not shown here.

LD name	LN Name	LN Description	Comments
ExtRcdTriggers	SUBSCRGGIO1	Generic process I/O	External Record Trigger Channels 1 to128
Output	SUBSCRGGIO1	Generic process I/O	Output Contact Control Channels 1 to 16
Records	RDRE1	Disturbance Recorder Function	Records
Triggers	DIGRBDR1 . . . DIGRBDR 128	Disturbance Recorder Channel Binary	Trigger Status of Digital Channels 1 to 128

Logical node specifications

The following sections provide detailed information on the I/O Expansion Logical Devices and Logical Nodes as defined in the previous sections.

Logical Device: ExtRcdTriggers

This section defines logical node data for the logical node SUBSCRGGIO1 of the I/O Expansion Logical Device ExtRcdTriggers.

Logical Node	Description	Data Attribute	Comments
SUBSCRGGIO1	External record trigger channels 1 to 128	ST$Ind1$stVal . . . ST$Ind128$stVal	Subscription: SUBSCR/Ind1 . . . Subscription: SUBSCR/Ind128

Logical Device: Output

This section defines logical node data for the logical node SUBSCRGGIO1 of the I/O Expansion Logical Device Output.

Logical Node	Description	Data Attribute	Comments
SUBSCRGGIO1	Output contact control channels 1 to 16	ST$Ind1$stVal . . . ST$Ind16$stVal	Subscription: SUBSCR/Ind1 . . . Subscription: SUBSCR/Ind116

Logical Device: Triggers

This section defines logical node data for the logical nodes DIGRBDR1 to DIGRBDR128 of the I/O Expansion Logical Device Triggers.

Logical Node	Description	Data Attribute	Comments
DIGRBDR1 . . . DIGRBDR128	Trigger status of digital channel 1 . . . Trigger status of digital channel 128	ST$ChTrg$stVal	GOCB and data sets for publication are user configurable

Logical Device: Records

This section defines logical node data for the logical node RDRE1 of the I/O Expansion Logical Device Records.

Logical Node	Description	Data Attribute	Comments
RDRE1	Start fault recording	ST$RcdTrg$stVal	
	Fault record completed	ST.RcdMade.stVal	
	Number of fault records	ST.FltNum.stVal	
	Fault recording started	ST.RcdStr.stVal	
	Memory used	ST.MemUsed.stVal	In percents

Index

A
alarm contacts 2-2
analog graph 10-5
analog input 7-11
analog input channels 8-9
autopoll 9-3
autoprint 9-3

C
channel grouping 8-6
communication ports 4-4, 4-20
configuation editor 8-4
configuration manager 8-1, 8-2, 8-3
connection status 5-5
control tabs 5-6

D
diagnostics 4-16
digital graph 10-5
DNP 8-12

E
edit configuration 8-2
element tree 8-7, 8-8
ethernet LAN link 4-7
event log 9-5
event messages 9-6
external input channels 2-2, 8-10, 8-11

F
fetch remote summary 9-3
front panel 1-5
front panel LEDs 2-2

G
get from IED 9-3
graph 9-3
graphs
- COMTRADE import 10-6
- digital channel status 10-6
- print 10-6
- records 10-1
- view menus 10-4

I
identification 8-5
install on Windows XP 3-2
installing TESLA 3-1
IRIG-B time input 4-5
IRIG-B time signal 2-2

M
maintenance menu 12-1
maintenance menu, commands 12-3
maintenance menu, error handling 12-5
metering 6-1
MODBUS 8-12
modem
- LAN gateway 4-14

modem link 4-14
mount TESLA recorder 2-1

N
navigating TESLA 5-6

O
offline operation 5-5
online operation 5-5

P
password
- protection 7-11
- setting 7-11

power supply 2-1
print
- configuration 8-12
- SCADA address list 8-12

printing 8-12

R
rear connections 1-5
record
- filter 9-2
- lists 9-2
- summary 9-3

RecordGraph
- components 10-3
- help menus 10-4
- launch 10-2
- menus 10-3
- tool bar 10-4

RecordGraph,
- launch 10-1

recordings stored 9-4
records 9-1
refresh 9-4
rename 9-4

S
SCADA services 4-14
scale menus 10-4
signal connections 2-2
specifications A-1

start-up 3-6
startup sequence 2-2
status bar 5-7
system requirements 3-1

T

trend log 9-5
trend logging 8-12
trigger fault 9-4

W

workspace 5-6
    settings 5-3